THE UNIVERSITY OF ALBERTA

MARKETING OF WOOD CHIPS FROM ALBERTA SAWMILLS

by

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ABSTRACT

In recent years, there has been an increasing demand for more efficient use of our resources. These demands of conservation; coupled with the growing needs for forest products, recreation, and fish and wildlife; have resulted in the concept of utilization becoming more significant. Further pressure to obtain efficient levels of resource utilization results from conflicting interests between various sectors using the forest resource.

Wood trimmings which result from the sawmilling process, have traditionally been burned as waste. The use of these sawmill residues as wood fibre input into the pulping process, results in a more efficient use of sawmill timber. There is, however, a significant potential for a greater and more efficient utilization of this resource. The specific problem in this study was to identify inefficiencies in the marketing of these wood chips which may restrict their utilization.

The primary objective of this study was to analyse the marketing of wood chips as to its effect on the utilization of the timber resource. The specific concern was to identify the pricing systems incorporated in marketing these chips. These objectives were pursued using a descriptive case study approach and comparative analysis.

The results of this study revealed that transport costs and the pricing policy of the pulpmills are the major factors restricting the utilization of wood chips from sawmills to pulpmills. The

combination of transport costs and pricing determines how far chips may be transported, and the consequent degree of utilization from sawmills located at various distances.

This study also revealed two pricing systems incorporated in marketing wood chips; uniform pricing and straight-line pricing. The uniform pricing system resulted in a greater degree of utilization of wood chips from sawmills. The major implication of this finding is that the potential for increased utilization exists through improving the pricing mechanisms to guide the flow of resources into efficient end-use products.

ACKNOWLEDGEMENTS

I wish to take this opportunity to express the sincere appreciation to my supervisor, Dr. M. R. Carroll for his continued guidance, support, and understanding throughout the course of this study.

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CHAPTER I

INTRODUCTION

With increasing demand placed on the forests by the forest products industry, and by other sectors such as recreation, fish and wildlife, and conservation, the concept of utilization of the entire forest resource is becoming more significant. Traditional pulp and paper industry practice of converting roundwood directly to pulp, is economically inefficient in face of competition for raw materials for conversion to building products.[1] The situation requires adoption of a total resource utilization concept and concomitant operational requirements. Industry management must commit itself to the goal of fully integrated operations based on economics of product trade-offs.[1] The largest problem in such trade-offs occurs with competition of the raw material from higher value building products. The use of wood residues from sawmills and plywood and veneer mills, through pulpmill chips becomes economical in light of such competition. This study analyzes the marketing of these wood residue chips with respect to efficiency of utilization. Efficient marketing of these chips ensures the use of wood residues and supports the total resource utilization concept.

The Importance of the Forest Products Industry

To represent the economic positon of sawmill chips in Alberta, it

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1. These conclusions were revealed by H.C. Mason in an article entitled "Innovation in the Forest Products Industry: Optimum Wood Usage," Located in: AlChem Symposium Series, (Vol. 70, No. 139, 1974), pp. 80-82.

is necessary to first describe the forest products industry. The impact of Alberta's forest products industry to the economic base is best measured by value-added. In terms of its contributions to the province as a whole, the value-added was 112 million dollars or 12.7 percent of the total value-added by the manufacturing industry in Alberta for 1972 (Table I-1). Its contribution for all Canada is similar at 13.0 percent of total value-added. Table I-2 shows Forestry's contribution to total value-added in goods producing industries for the years 1969 to 1974. It has fluctuated around 0.3 percent.

Other principal statistics placed wood-based industries in a more significant position than value-added statistics.[1] Shipments (exports) of $239 million from wood-based industries accounted for 9.8 percent of Alberta's manufacturing sector. Similarly, Alberta's wood industry provided 13.6 percent of the employment and 13.0 percent of the salaries and wages compared with the total provincial manufacturing industries in 1972 (Table I-3). For all Canada, wood-based industries provided slightly less of the employment at 13.3 percent, and more of salaries and wages at 14.2 percent.

A further aspect of the industry in the province lies in the location of mills. These locations throughout the province are in areas where there is little other industry. In such industrial locations, stimulation of the local economies can help to alleviate regional disparities within the province.

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1. Teskey, A.G. & Smyth, J.H., The Economic Importance of Sawmilling and Other Primary Wood-Using Industries in Alberta, 1972, Information Report NOR-X-145, (Canadian Forest Service, November, 1975), p. 23.

In general, the utilization rates of Canadian forests are quite low.[1] Alberta has surplus wood fibre in most forests, allowing for opportunities to expand and develop the industry.[2] The theoretical maximum, given by Teskey and Smyth is six times the size of the industry operating in 1972.[3] Such expansion would dramatically increase its importance to the Alberta economy.

TABLE I-1 VALUE-ADDED FOR THE FOREST PRODUCTS INDUSTRY AS COMPARED TO ALL OTHER INDUSTRIES. 1972.

--$'000-- INDUSTRY GROUP	TOTAL ACTIVITY/VALUE ALBERTA	%	CANADA	%
WOOD INDUSTRIES	81,848	9.24	1,422,423	5.46
PAPER & ALLIED INDUSTRIES	30,534	3.44	1,961,576	7.54
SUB TOTAL	112,382	12.68	3,383,999	13.00
ALL OTHER INDUSTRIES	773,076	87.32	22,630,265	87.00
TOTAL	885,458	100.00	26,014,264	100.00

Source: Statistics Canada, Catalogue Number 31-201P, -203P, -204P, -205P, -260P, -207P, -208P.

1. Utilization is defined in this study as the percentage of wood residues processed into pulpwood chips as distinct from the percentage of standing timber transformed into final products.
2. Surplus here refers to excess supply over immediate demand (industrial capacity).
3. *Ibid.*, p. iii. The theoretical maximum is the maximum yield of the forest resource (the total utilization of the annual allowable cut). Annual Allowable Cut is defined in CHAPTER III.

TABLE I-2 CENSUS VALUE-ADDED IN GOODS PRODUCING INDUSTRIES AND PERCENTAGE ANALYSIS FOR ALBERTA. 1969 - 1974.

INDUSTRY	1969		1970		1971	
	$'000	%	$'000	%	$'000	%
FORESTRY[1]	7,028	0.2	8,695	0.3	10,006	0.2
AGRICULTURE	555,259	17.2	528,186	15.5	555,943	14.5
OTHER INDUSTRY COMBINED	2,661,889	82.6	2,861,582	84.2	3,351,479	85.3
GRAND TOTAL	3,224,356	100.0	3,398,453	100.0	3,817,428	100.0

INDUSTRY	1972		1973		1974	
	$'000	%	$'000	%	$'000	%
FORESTRY[1]	12,234	0.3	21,579	0.4	26,362	0.3
AGRICULTURE	623,905	14.5	1,076,647	17.9	1,284,031	15.1
OTHER INDUSTRY COMBINED	3,771,952	85.2	4,921,662	81.7	7,190,253	100.0
GRAND TOTAL	3,408,091	100.0	6,019,888	100.0	8,500,646	100.0

Source: Statistics Canada Catalogue Number 61-202, Survey of Production (Table 5)

1. Forestry data excludes stumpage. As well, this data represents only logging. Other wood industries were included under other industry combined.

Table I-3 EMPLOYMENT IN THE MANUFACTURING INDUSTRIES OF ALBERTA AND CANADA BY INDUSTRY GROUP 1972

	TOTAL EMPLOYEES (NUMBER)				TOTAL ACTIVITY BASIS SALARIES AND WAGES (DOLLARS)			
INDUSTRY GROUP	ALBERTA	%	CANADA	%	ALBERTA	%	CANADA	%
WOOD INDUSTRIES	5,717	10.54	102,699	6.13	41,331	9.56	770,902	5.75
PAPER & ALLIED INDUSTRIES	1,680	3.09	120,758	7.21	14,897	3.44	1,135,298	8.46
SUB TOTAL	7,397	13.63	223,457	13.34	56,228	13.00	1,906,200	14.21
ALL OTHER INDUSTRY	46,798	86.37	1,451,362	86.60	377,099	87.00	11,499,153	85.79
TOTAL	54,195	100.00	1,674,819	100.00	432,327	100.00	13,405,353	100.00

Source: Statistics Canada, Catalogue Number 31-201P, -203P, -204P, -205P, -206P, -207P, 208P.

Need for the Study

Utilization of the forest resource commands a substantial volume of literature on its behalf. Concern in this area stems from both social and economic pressures. As society becomes aware of the importance of making the most of our resources, new technology and economic forces are increasing the supply of wood fibre through the utilization concept. As energy sources become depleted, more stress may be placed on wood as an alternative.

Projection analyses carried out in the Western Forest Products Laboratory over the past five years have indicated that by the year 2000, or within 25 years, the total world demand for wood will be in the order of 4000 million cubic metres(m^3).[1] This value is based on three primary assumptions:

(1) that historical trends in the use of wood for plywood, lumber, fibre products and solid products will continue;

(2) that there will be no major erosion of traditional end uses for wood by metals, synthetic resins, products derived from rocks, sand or dirt, or recycle; and

(3) that use of wood for fuel will continue to be approximately 50 percent of total wood cut.

Projections made by Manning and Grinnell,[2] predict the demand for roundwood to grow at an annual rate of 2.2 percent; and that some of this increase will be met by the use of wood residues in the pulping industry. The use of these wood residues is projected to grow at 3 percent a year to 16 percent of all the raw material used.

This quantity of demand projections place increasing stress on the utilization of our forests. The role of wood chips in light of these predictions lies in using the resource to its fullest potential. By insuring efficient use of these chips, and consequent supplies, a step towards increased utilization may be achieved. This will be encouraged by a positive attitude towards total forest utilization.

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1. Keays, J.L. & Hatton, J.V., "The Implication of Full-Forest Utilization on Worldwide Supplies of Wood by Year 2000," Pulp and Paper International, (June 1975), p. 51.
2. Manning, G.H. & Grinnell, H.R., Forest Resources and Utilization in Canada to the Year 2000, Publication No. 1304, (Department of the Environment, Canadian Forestry Service, Ottawa, 1971), p. 2.

Problem

The specific problem of concern in this study lies in the marketing of wood chips from sawmills to pulpmills in Alberta, and to identify any inefficiencies which may restrict utilization. With the change in attitude towards the forests from one of "inexhaustible supply" to "necessity for preservation for future generations," the use of wood residues into the pulping process has increased.[1] To ensure that the full potential of the resource is being achieved, efficient marketing of these residues is necessary.[2] Efficient marketing will result in higher economic value for these chips, and, as well will insure that this new precept is secured.

It seems apparent that factors such as low concentrated timber resource, and somewhat inefficient freight systems are driving up the transportation costs and resulting cost of chips to the pulpmill.[3] Consequently, this reduces the net return back to the sawmiller.[4]

Figure I-1 shows the Canadian forest industries material balance. The sawmill residues to pulp production part of the cycle allows interpretation of the perspective of the problem in Alberta. The percentage of such residues transferred is a significant portion of the forest products output. It is greater than lumber shipments, in tons, and is almost 24 percent of the total cut.

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1. Environmental Planning and Engineering Consultants (EPEC) Consulting Western Limited, The Forest Resource in Alberta, (Limited distribution report to Environment Conservation Authority, 1972), p. 1.
2. Efficient marketing tends to ensure utilization of waste products and hence approaches maximum value added.
3. Concentration here refers to the locational characteristics of the sawmill industry; that is, a widely spread industry.
4. Rodger, B., "There's a Boom Coming," British Columbia Lumberman, (February 1977), p. 32.

Fig. I-1 CANADIAN FOREST INDUSTRIES MATERIAL BALANCE - MILLION TONS PER ANNUM

Total cut

Remains in forest

Lumber operations

Pulp wood

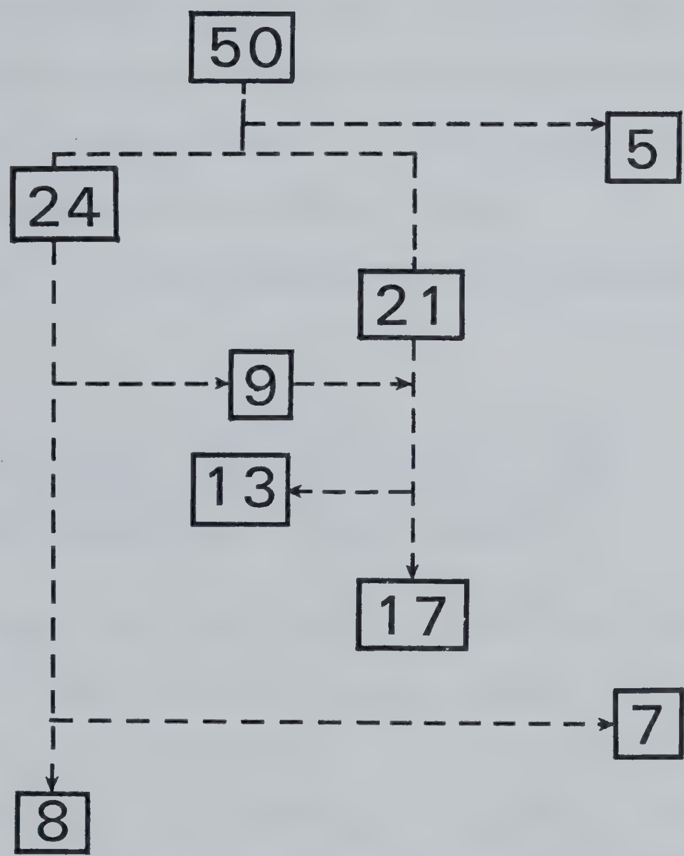
Sawmill residues to pulp production

Pulping wastes, dissolved and burned

Pulp and paper shipments

Sawmill wastes

Lumber shipments



Total Recoverable 12

Factors: 100 cu. ft. roundwood = 1.25 tons

1000 fbm = 1.04 tons

1 ton pulp and paper = 0.92 tons fiber

Source: Pequegnat, C. (Editor), Waste Recycling in Canadian Agriculture, (Agricultural Economic Research Council of Canada, Conference Proceedings: "Commercial Uses of Wastes as Animal Feed," Toronto, April 24-25, 1975), p. 66.

Objectives and Goals of the Study

The primary objective of this study is to analyze the marketing of wood chips as to its effect on the utilization of the timber resource. The specific concern here is the pricing system incorporated in the marketing of these chips. Two further objectives are; first, to describe volumes and flows of these sawmill chips, and secondly, to develop recommendations as to improvements in this marketing system to increase the utilization of chips.

The basic problem led to the formulation of the following primary hypothesis:

> The market structure in existance for the procurement of wood chips is inefficient with respect to their utilization, and therefore restricts the potential flow of wood chips as input into pulp production.

By testing this hypothesis, the study hopes to establish the relative efficiency of wood chip flows into the pulping process. Testing of this hypothesis is done using a descriptive case study approach and comparative analysis. This deterministic approach was used as statistical verification of the data was not possible because of sample size.

Scope

The function of marketing wood chips is that of creating an economic value from a resource which is otherwise waste. The creation of such value includes physical change in the resource, physical

handling and transportation, and various buying and selling activities. The marketing process results in the utilization of this waste material. Optimum utilization depends on this process being efficient.

The analysis of wood chip utilization in this study, is limited to Alberta. The marketing process studied is carried out within the boundaries of the province. It is hoped that this study will show constraints which may be overcome not only in Alberta, but in other areas utilizing waste wood chips.

The following chapter presents the economic theory supporting the analysis. Chapter III discusses the forest products industry in Alberta with a history, resource disposition and description of current structure. Chapter IV is the methodology, which describes data sources and the procedure followed in its procurement. Chapter V is the case studies and comparative analysis. Chapter VI discusses conclusions, recommendations, and implications of the study.

CHAPTER II

BASIC CONCEPTS

The purpose of this chapter is to discuss the relevant theoretical concepts which support the analysis in this thesis and the basic elements of imperfect market structures and resulting pricing systems.

Industrial organization is a theoretical and empirical study of how the structure of the organization and conduct of sellers affect economic performance and economic welfare.[1] Figure II-1 illustrates these relationships between market structure, conduct and performance and places the theoretical concepts discussed in this chapter into their relative position in the industrial organization scheme.

Market Structure

Market structure is defined by Bain as; "those characteristics of the organization of a market that seem to exercise a strategic influence on the nature of competition and pricing within the market."[2] The nature of competition and pricing within the market determines the quality of the industry's performance in that market.

The major elements of market structure which affect the behavior

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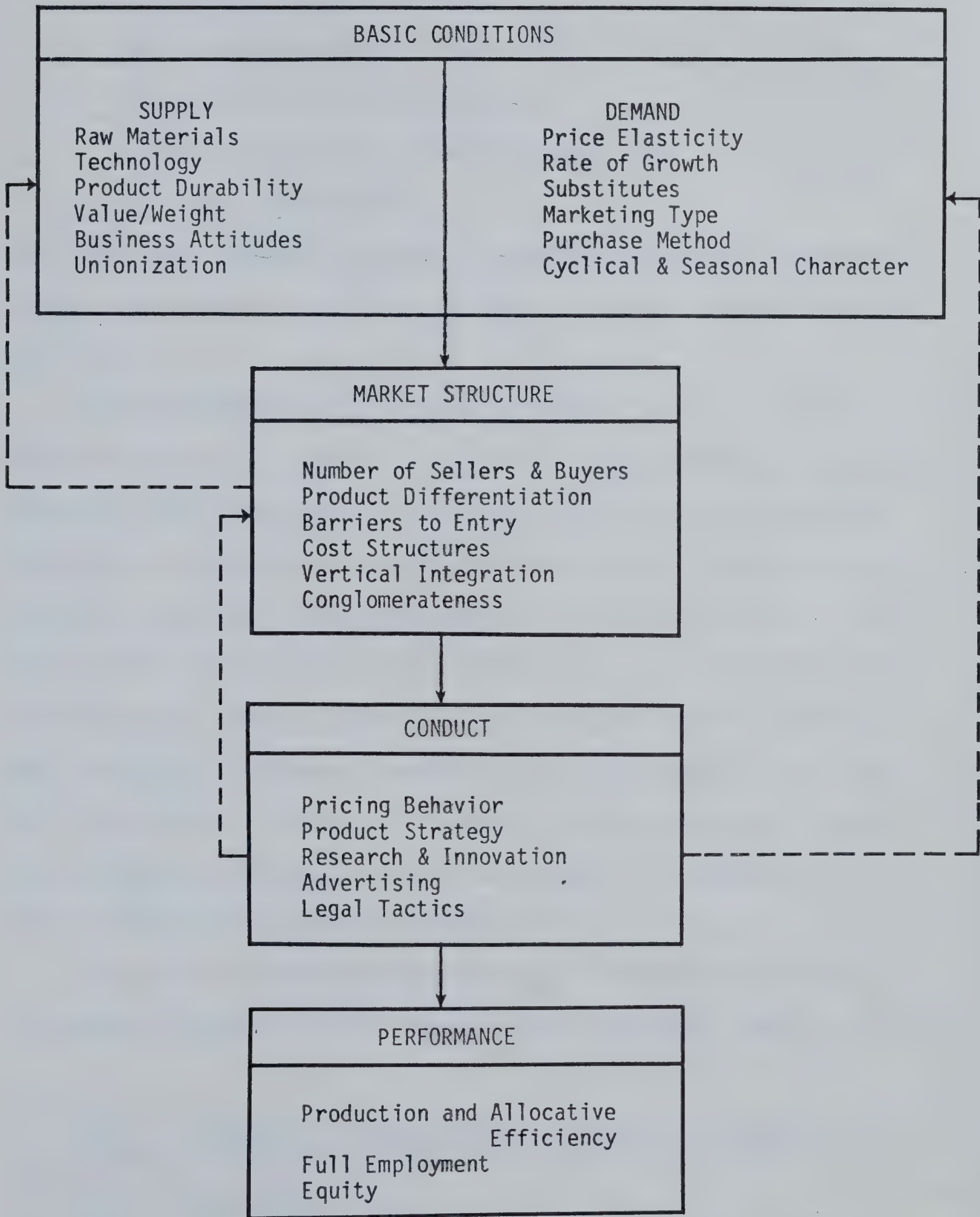
1. Koch, J.V., Industrial Organization and Prices, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1974), p. 3.
2. Bain, J.S., Industrial Organization, 2nd Ed. (New York: John Wiley & Sons Inc., 1968), p. 7.

FIGURE II-1
A MODEL OF INDUSTRIAL ORGANIZATION
ANALYSIS



Source: Koch, J.V., op. cit., p. 6.

of firms in an industry are:[1]

1) Seller Concentration,
2) Product Differentiation,
3) Barriers to Entry of New Firms,
4) Growth Rate of Market Demand,
5) Price Elasticity of Market Demand, and
6) Buyer Concentration.

The first three elements are normally considered to be more important as they have a more significant effect on conduct and performance variables.

Seller concentration is referred to by Bain[2] as to whether the number of sellers in a market is one, few, or many (monopoly, oligopoly, atomistic) and to the relative sizes of sellers with any given number. The degree of seller concentration significantly influences the character, intensity, and effectiveness of competition among sellers. Caves states that "highly concentrated industries are likely to perform poorly because they allocate resources inefficiently - employing too few factors of production and channelling too many into less concentrated industries."[3] Concentration is measured by a four-firm concentration ratio, giving the percentage of an industry's total sales accounted for by the four leading firms.[4]

The distinction between homogeneity and differentiation hinges on the degree of substitutability among sellers' products.[5] Where homogene-

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1. Caves, R., American Industry: Structure, Conduct, Performance, 3rd ed., (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972), p. 16.
2. Bain, J.S., op. cit., p. 8.
3. Caves, R., op. cit., p. 17.
4. Scherer, F.M., Industrial Pricing: Theory and Evidence, (Chicago: Rand McNally College Publishing Co., 1970), p. 3.
5. Ibid., p. 2.

ity exists, products are perfect substitutes. When one product is preferred over another due to differences in physical attributes, ancillary services, geographic location, and/or subjective image; product differentiation exists. Bain states that "the extent to which competing products in a market are differentiated, influences the competitive interrelationships of sellers in the market, their conduct, and their market performance."[1]

Barriers to entry serve as a structural trait in that the condition of entry reflects potential rivals and competition by the highest price which will just fail to tempt new firms into the industry.[2] In an analysis by Bain it is stated that "this condition of entry characterizes the extent to which established sellers have advantages over potential entrant sellers, and determines the relative force of potential competition as an influence or regulator on the conduct and performance of sellers already established in a market."[3]

The other elements of market structure given by Caves[4] are demand growth, demand elasticity, and buyer concentration; and affect conduct and performance variables, in a somewhat lesser manner.

Market Conduct

Caves[5] defines the behavior of firms in changing prices, output, product characteristics, selling expenses, and research expenditures as their market conduct. Clark states; "that market conduct or business

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1. Bain, J.S., op. cit., p. 8.
2. Caves, R., op. cit., p. 23.
3. Bain, J.S., op. cit., p. 8.
4. Caves, R., op. cit., p. 30.
5. Ibid., p. 36.

behavior, an intermediate term, is both result and cause."[1] Conduct is the result of market structure, and in turn results in a certain quality of performance.

Market conduct is divided into three areas:[2]

1) policies toward setting prices,
2) policies toward setting the quality of the product, and
3) policies aimed at coercing rivals.

The most significant element of market conduct in this study is the setting of prices. Bressler and King state; "that the direct objective of the marketing system is providing for and participating in price formation; and that the prime function of the pricing system is the guiding of the flow of resources into production and of goods and services into consumption."[3]

The underlying importance of such pricing involves efficiency conditions, and resulting market performance.

Market Performance

Bressler and King[4] describe market performance as the real impact of structure and conduct as measured in terms of variables such as prices, costs, and volume of output. In a broader definition, Bain describes market performance; ". . . the crucial indicator of how well the market activity of firms had contributed to the enhancement

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1. Clark, J.M., Competition As A Dynamic Process, (Washington, D.C.: The Brookings Institute, 1961), p. 422.
2. Caves, R., op. cit., p. 37.
3. Bressler, R.G., & King, R.A., Markets, Prices, and Interregional Trade, (New York: John Wiley & Sons, Inc., 1970), p. 411.
4. Ibid., p. 409.

of general material welfare."[1]

Market performance is best illustrated by efficiency measurements. Kohls[2] relates two measures of efficiency to market performance: technical efficiency and economic efficiency. Technical or operational efficiency concerns the various contributions which science and technology make toward reducing the costs of resources necessary to produce the final product. Economic efficiency is concerned with maintaining the competitive aspects of marketing. Such a definition, by Kohls, is very broad and is more specifically placed as allocative efficiency and pricing or exchange efficiency. Bain states that; "allocative efficiency concerns the amount of scarce productive resources allocated to producing the industry's output."[3] An optimal allocation would be the output by all firms where each productive resource had the same marginal productivity in every industry. This optimal or ideal allocative efficiency criteria is illustrated in the competitive model of perfect competition.[4] In this model long-run average cost equates to long-run marginal cost and to price.[5] The effective profit rate is zero giving ideal allocative efficiency for the industry. Bain's interpretation of allocative efficiency and profit rates may be compared with Bressler and King's[6] description of pricing efficiency. This efficiency condition is

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1. Bain, J.S., op. cit., p. 372.
2. Kohls, R.L., Marketing of Agricultural Products, 3rd ed. (New York: The Macmillan Co., 1967), p. 9.
3. Bain, J.S., op. cit., p. 374.
4. Ibid., p. 393.
5. The model of perfect competition is discussed briefly later in this chapter.
6. Bressler and King, op. cit., p. 413.

appraised through contrast of actual prices with ones generated by some efficiency model, usually associated with the perfectly competitive norm. Pricing efficiency is considered to be a measure of how well prices perform their prime function; the guilding of the flow of resources into production.

Market Structure & Pricing

Scherer[1] classifies five basic market structure types that depend upon the number of sellers and the nature of the product. Figure II-2 shows these market structures which result in different kinds of conduct. The specific conduct variable of concern here is pricing. The observation of pricing systems resulting from certain types of market structures is a good indicator of market performance when considered in association with efficiency conditions. This section concentrates on the imperfectly competitive pricing models of oligopoly and monopoly and their extensions as applicable to the marketing of wood chips.

Perfectly Competitive Model

The perfectly competitive model is employed as a representation of the optimimum, a measuring stick against which all other circumstances and market structures may be compared and evaluated.[2] The assumption of perfect competition simplifies the analysis of markets and permits economists to carry the analysis of market forces to an equilibrium point.[3]

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1. Scherer, F.M., op. cit., p. 1.
2. Koch, J.V., op. cit., p. 16.
3. Dooley, Peter C., Elementary Price Theory, (New York: Meredith Publishing Co., 1967), p. 66.

Working from this ideal focal point the analysis of imperfect market structures through practical case studies reveals that such imperfections retard the movement towards the perfectly competitive equilibrium position.[1]

FIGURE II-2

MARKET STRUCTURE TYPES

Type of Product	Number of Sellers One	 A Few	 Many
Homegeneous	Pure Monopoly	Homogeneous Oligopoly	Pure[2] Competition
Differentiated Product	Pure Monopoly	Differentiated Oligopoly	Monopolistic Competition

Source: Scherer, F.M., op. cit., p. 1.

1. The theory of the perfectly competitive model of pricing is not discussed in detail here. The two preceding references deal with the theory, as do some of the references at the end of the thesis.
2. Perfect competition is differentiated from pure competition by the assumption of "perfect information". This difference is noted by J.V. Koch, op. cit., p. 17.

Pure Monopoly

A pure monopoly exists when there is only one seller in a given market. Bain states; "that the single seller has complete control of the market price at which he sells and may raise it or lower it while effectively restricting or expanding the amount of product he sells."[1]

The basic assumptions to the model of pure monopoly are:[2]

1. A single seller exists in the market for this product;
2. The single seller produces a differentiated product[3] for which there are no ready substitutes (cross-elasticity is close to zero); and
3. Substantial barriers to entry exist.[4]

Monopoly equilibrium is attained when profits are maximized.[5] Profits are maximized when marginal revenue is equated to marginal cost. Because the monopolist is a price maker rather than a price taker his demand curve is downward sloping and at any given quantity sold, marginal revenue will be less than price because the monopolist must successfully lower his price in order to sell additional units of output.[6] Graph II-1 illustrates the monopolist's position in the short run. Pure profits here are BA per unit, and total pure profits earned

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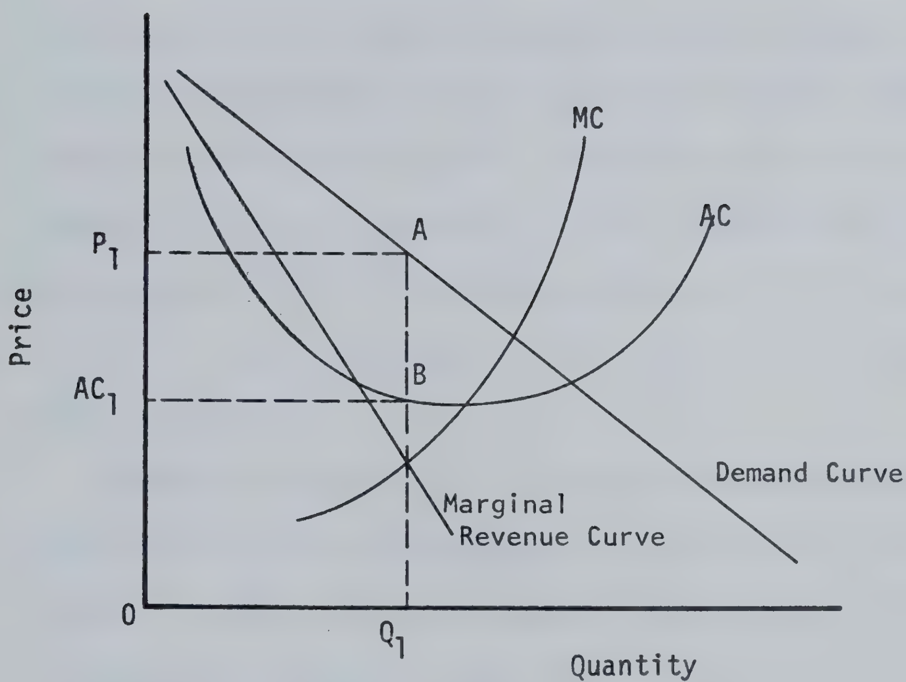
1. Bain, J.S., op. cit., p. 28.
2. Koch, J.V., op. cit., p. 22.
3. Products are differentiated when they are preferred over other products due to differences in physical characteristics, geographic location, and/or subjective image. See: Scherer, F.M., op. cit., p. 2.
4. This assumption is critical to the maintenance of monopoly power in the long run.
5. Dooley, P.C., op. cit., p. 84.
6. Koch, J.V., op. cit., p. 22.



GRAPH II-1

MONOPOLY EQUILIBRIUM

Source: Dooley, P.C., op. cit., p. 85.

by the monopolist are equal to the area rectangle AC_1, P_1, A, B. Such pure profits[1] ordinarily attract the entry of new firms. However since substantial entry barriers exist, the price-quantity solution in Graph II-1 is also the long-run solution.

Monopolistic output restriction and monopolistic excess profits emerge from this form of pricing. The welfare criterion of the perfectly competitive model is violated under monopoly pricing, and because of output restriction, a less than optimal (least-cost) scale and rate of utilization results. Bain states; "that no definite or unique prediction can be made as to the technical efficiency of the monopolist as that is influenced by the scale of his operations."[2] However, in terms of allocative efficiency, the monopolist violates pareto-optimality.[3]

Monopoly may also exist in the buying of resources. A resource market situation in which there is a single buyer of a particular resource is called one of monopsony.[4] Quirk states; "that under a monopsony with an upward sloping supply curve of the input, price paid

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1. Pure profits or economic rent may be simply defined as the residual excess received by or for a firm's owners, of the sales revenue of the firm over all costs incurred to earn the revenue. Economic rent can be viewed largely as a short run economic surplus that a productive factor can earn because of unexpected demand or supply conditions under pure competition. Further discussion on economic rent may be found in: Barlowe, R., Land Resource Economics, 2nd ed. (Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1972), p. 158.
2. Bain, J.S., *op. cit.*, p. 28
3. The pareto-optimum, a term used by welfare economists, exists when no one can be made better off without making someone worse off. The power of the monopolist to change output violates this basic welfare meaning of maximum material welfare.
4. Leftwich, R.H., The Price System and Resource Allocation, 3rd ed. (New York: Holt, Rinehart and Winston, 1966), p. 278.

per unit of the input is lower than would be the case under perfect competition, and fewer units are hired."[1] Graph II-2 illustrates monopsony equilibrium. As in the case of monopoly, monopsony leads to a non-pareto-optimal allocation of resources in the economy. In equilibrium, the monopsonist does not maximize Gross National Product (GNP), or total output over the production possibility set but rather at some point less than optimal. In regards to purchasing wood chips, the monopsonist reduces the quantity purchased and the price paid for chips. Gregory states; "that the extent of this price reduction and the degree to which monopsonistic power can be effective will depend primarily on the elasticity of the supply curve."[2]

Oligopoly

The term oligopoly is typically applied to a market characterized by the existence of a few large firms.[3] The fundamental nature of this market form is the high degree of interdependence among the decisions of the firms, resulting in firms's attempting to predict competitors' reactions to various decisions. The degree of risk and uncertainty which stems from this form of market structure, has resulted in the formation of numerous theories of pricing conduct. Such theories range from Chamberlin's[4] theory of monopolistic competition to those

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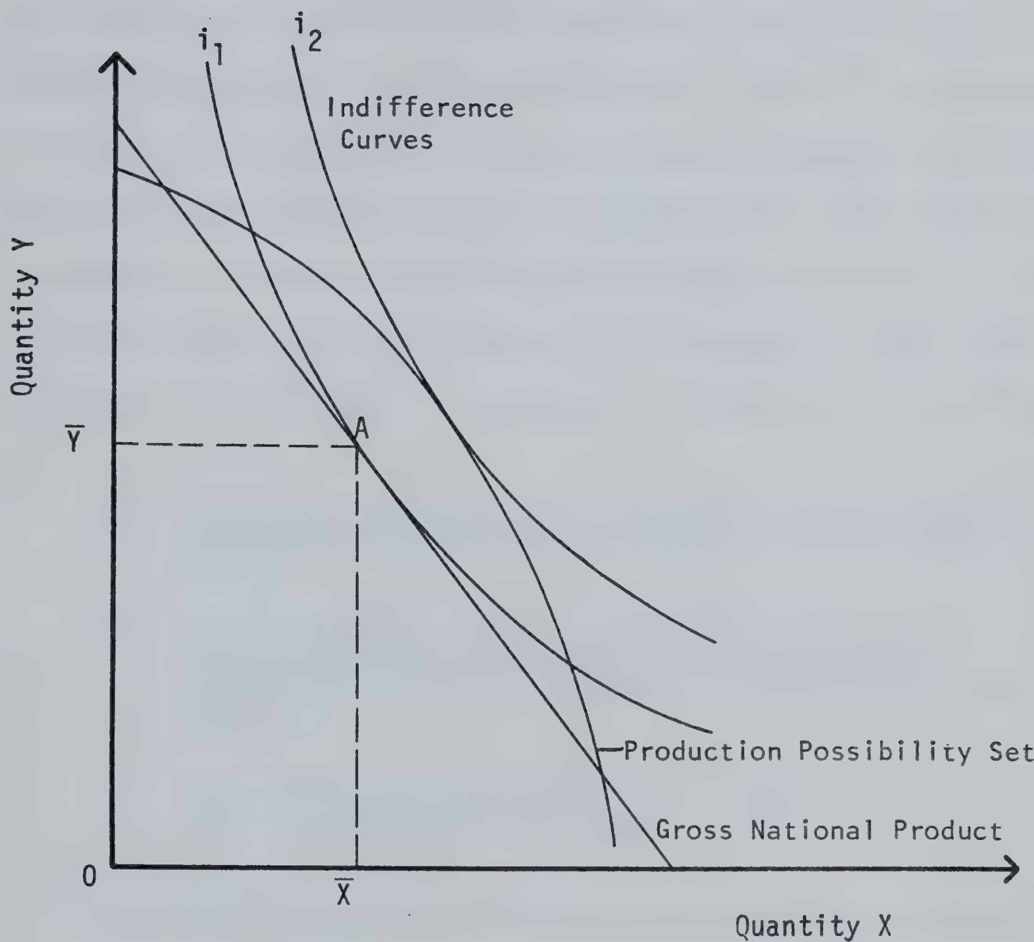
1. Quirk, J.P., Intermediate Microeconomics, (Chicago: Science Research Associates, 1976), p. 264.
2. Gregory, G.R., Forest Resource Economics, (New York: Ronald Press Co., 1972), p. 370.
3. Koch, J.V., op. cit., p. 267.
4. Chamberlin, E.H., The Theory of Monopolistic Competition, (Harvard University Press, 1948), Chapter 5.



GRAPH II-2

MONOPSONY EQUILIBRIUM

of 'open' oligopoly and cost-plus-markup pricing.[1]

An oligopoly may also exist in a resource market situation. Oligopsony is described as a resource market in which there are a few buyers of a particular resource which may or may not be differentiated.[2] One buyer takes a large enough proportion of the total supply of the resource to be able to influence the market price of the resource. If there are only a few buyers in an area with many sellers, the theoretical effect on price can vary greatly. Gregory states that; "at one extreme oligopsony could have the same effect as that of monopsony.[3] The possibility of either collusive oligopsony or development of price leadership, forcing a similar effect to monopsony, is tempered by three facts:

1. The actual effect on price will depend on the elasticity of both the demand and supply curves for the product in question.

2. Any oligopsonistic buyer, when considering a price reduction, would be limited by the knowledge that other buyers might "bid-up" the price to undermine his position.

3. Since buying price agreements are illegal there is little hope of enforcing them.

The market facing the oligopsonist buying the resource from a competitive seller would influence the behavior of the oligopsonist. Whether or not the action of an oligopsonist would depress resource prices below those possible attained under competitive conditions

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1. The theories of oligopoly pricing are not discussed in detail here. For a discussion see: i) Koch, J.V., _op. cit._, pp. 267-290; and ii) Leftwich, R.H., _op. cit._, Chapter 11.
2. Leftwich, R.H., _op. cit._, p. 278.
3. Gregory, G.R., _op. cit._, p. 369.

depends on the specific case in question. Gregory[1] makes reference to an example of a pulpwood plant, where prices maintained were higher than under perfectly competitive conditions. The major reason for this, was to maintain good supply relations.

Other Pricing Structures

It is important to place pricing structures in context because the pricing policy of the pulpmills is critical to the study. Further, the location of producers and markets with respect to one another, may induce a pricing structure which is detrimental to competition. In a discussion on supply areas, Hoover states:[2]

> that the locational relations between two successive stages of production can be pictured either as a system of market areas or as a system of supply areas, depending on whether the earlier or the later stage is more concentrated. The formation of supply areas is thus analagous to the formation of market areas.

Hoover states further that, "the shape of market or supply areas is influenced by the advantages of different locations for procurement and processing and by the structure of transfer costs."[3] Such market or supply areas normally result in some type of pricing structure. The following text discusses pricing structures arising from the problem of competition over distance, and looks at their effects upon the competitive nature of producers operating within such geographical market areas.

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1. Ibid., p. 369.
2. Hoover, E.M., The Location of Economic Activity, (New York: McGraw-Hill, Inc., 1948), p. 61.
3. Ibid., p. 65.

Uniform Price or Postage Stamp System: Under this system, a uniform delivered price is charged to every buyer, regardless of distance from the production source. The producer absorbs the higher freight costs on shipments to customers near its plant. The uniform price may exceed the freight costs to close customers and the producer collects what is called phantom freight. For the market situation in the purchase of wood chips, the buyer would absorb the higher freight costs through purchases from near mills, whose transport costs are less. Such a strategy discriminates in favor of distant customers. This type of system is used mostly with commodities whose value is high relative to transport costs and also for items whose price is nationally advertised and therefore must be kept uniform.

Uniform F.O.B. Mill Pricing: A mill price is set at which customers may buy, paying their own freight bills; or, if delivery by the producer is preferred, the actual charges for transportation from the producing mill to the buyer's destination will be added onto the mill price. If each mill adheres to its F.O.B. mill pricing policy, neither can sell in the other's territory. That is, assuming the same transport costs, at a point half-way between two producers there will be equal advantage. As the distance gets less for one relative to the other, we observe a territory in which that particular producer has an advantage.

F.O.B. Mill Pricing; Unsystematic Discrimination Through Freight Absorption: This involves undercutting of prices by absorbing the freight costs. This results in uncertainty as to how low a price must be quoted to win territory and consequently can cause a breakdown in oligopoly disipline.

Basing Point Pricing: Basing point pricing is used most frequently by oligopolists selling physically standardized products whose transportation costs are high relative to product value and whose marginal production cost is low relative to unit cost. Koch states that, "basing point pricing usually implies a pricing system by which the delivered price paid by the purchaser is the sum of some mill price plus freight costs from some basing point to the customer."[1] The mill price is the free on board (F.O.B.) price at the mill location. The first type is the Single Basing Point system. In this system, one production point is accepted by common consent as the basing point, and all prices are quoted as the announced mill price at that point plus freight (usually rail) to destination. What is observed is that freight charges are quoted regardless of the actual shipping point or actual freight charges observed by the seller. The second type is the Multiple Basing Point system. Here more than one producing mill is designated as a basing point, and the delivered price quoted to any given customer reflects the lowest applicable basing point price plus freight to destination. The incidence of phantom freight is reduced here, as it is gained only by non-base mills.

In concluding, basing point pricing weakens competition and increases price rigidity in the market. This system of pricing, especially the single basing point system, is discriminatory. Competition is restricted because of the reduction of a complicated price quotation problem which would of prevailed had this system not developed. This pricing system in effect eliminates discretion and

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1. Koch, J.V., op. cit., p. 302

uncertainty, thus avoiding price competition.

The interrelationships of market structure, conduct, and performance help to explain the economic behavior of firms in an industry. This study looks at the importance of pricing policies and transport costs in the utilization of wood chips from sawmills to pulpmills in Alberta. The above discussion of market structures and their impact on pricing, places the study into perspective. Through an explanation of economic behavior, and a comparative analysis using practical industry data from the questionnaire survey, this study purports to provide an indication of industry performance with respect to the efficiency and utilization of wood chips.

CHAPTER III

THE ALBERTA SCENE

The Resource

This section provides an overview of the forest resource in Alberta.[1] The entire area of the province of Alberta encompasses 255,000 square miles. Of this area, approximately 150,000 square miles are forested lands, which are divided into ten regions of administration known as forests. These are the Athabasca, Bow-Crow, Clearwater-Rocky, Edson, Footner Lake, Grande Prairie, Lac La Biche, Peace River, Slave Lake, and Whitecourt Forests. (See Figure III-I).

The majority of the area in each forest is divided into forest management units of approximately 1,389 square miles in size. Agricultural development is restricted in these areas. There are 108 forest management units established in Alberta. The management units form the geographical basis of a forest management program, the principal objective of which is to maintain maximum forest production on a sustained yield basis.[2] The area under management totals approximately 127,000 square miles. Of the remaining 23,000 square miles,

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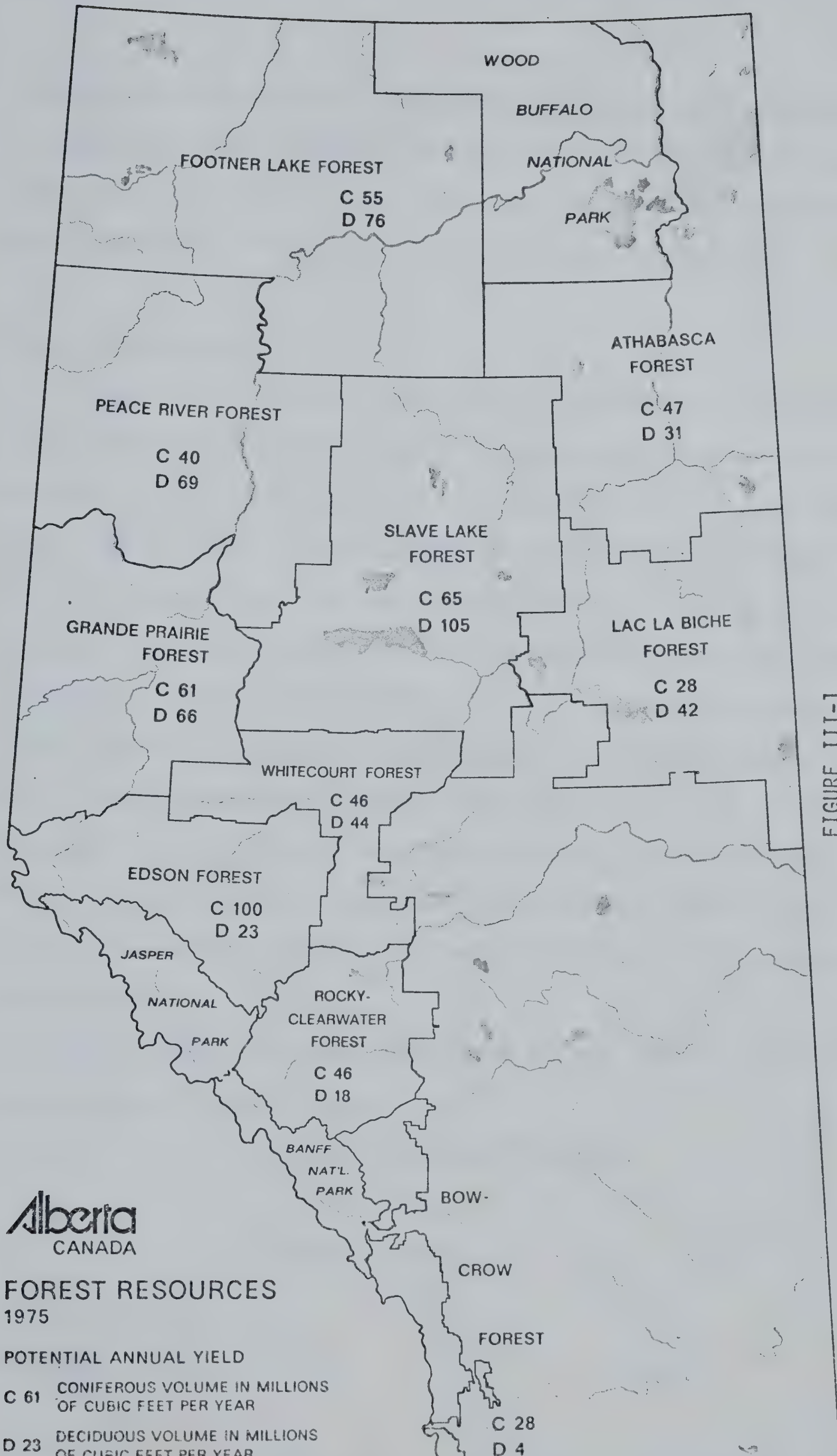
1. Much of the information for the overview was provided by a report by EPEC Consulting Western Limited, op. cit., p. 3.
2. A forest area managed under a policy of sustained yield is managed to provide a periodically equal output of forest products, rather than a declining or terminating flow. For further detail on Sustained Yield Forest Management see, A Review of the Quota System of Timber Disposition in Alberta, Alberta Forest Service, (February 9, 1972), p. 6.



Source: Alberta Transportation, Maps and Surveys Branch.

FIGURE III-1
GEOGRAPHICAL LOCATION OF FORESTS IN ALBERTA

17,000 square miles are "0" areas, upon which agricultural development is permitted, and 2,000 square miles each are Metis colonies, wilderness areas, and other areas. Figure III-2 shows the permanent forest lands, existing agreement areas, large sawmill centres, and pulpmills.

Timber Disposition

"Timber cutting rights were first sold in Alberta in the 1880's. From that time until May 1, 1966, the basic method of timber disposal had been to sell Timber Licences to the highest bidder."[1] It was found that, "the policy of selling licences to the highest bidder, regardless of other licencees and investments adjacent to the timber being sold, resulted in unreasonable overbids and operating costs for many timber licencees."[2] Without the security of long term supply it was difficult, if not impossible to get the forest products industry to make the large capital investments necessary to develop remote areas. In order to ensure a sustained yield of forest products as a basis for permanent industries and communities, the provincial government implemented the quota system of timber disposal on April 12, 1965, with an amendment to the Forests Act 1961.[2]

Certain rights over crown timber may be obtained in Alberta by acquiring one of the following:

1. Forest Management Agreement
2. Timber Quotas
3. Timber Permits

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1. Ibid., p. 4.
2. Ibid., p. 7.

FIGURE III-2
MAJOR INDUSTRY LOCATIONS AND FOREST LANDS

Source: Alberta Transportation, Maps and Surveys Branch.

1. Forest Management Agreements are entered into only when the applicant agrees to construct a pulpmill, plywood plant, or some other large capital facility to process the fibre resource from an agreement area. At the present time, there are five active Forest Management Agreements in Alberta. They are held by North Canadian Forest Industries Limited, who operate a large studmill, planermill, and plywood plant near Grande Prairie; Proctor and Gamble Cellulose Limited, who are presently operating a large pulpmill near Grande Prairie; North Western Pulp and Power Limited, who are operating a pulpmill and studmill at Hinton; Simpson Timber Company, who are operating a large sawmill at Whitecourt and North Canadian Forest Industries who operate a studmill at Hines Creek. Each Forest Management Agreement provides almost exclusive harvesting rights over extensive areas of commercial timber to agreement holder, at specified dues rates and under specific conditions. Forest Management Agreements are twenty year renewable based on adequate management performance, and in all cases, the holder of the agreement is required to manage his property on the basis of sustaining the yield or flow of production indefinitely into the future, and the agreement holder is required to reforest cut areas.

2. Timber Quotas: The Department of Energy and Natural Resources undertakes to establish the amount which may be cut annually on a sustained yield basis for each of its forest management units, where sawtimber is available for cutting in commercial quantity from permanent forest land. A quota authorizing a proportion of approved

annual production may then be offered for competitive sale at public auction. Bids are received in units of one hundred dollars, and the highest bidder receives the quota.[1] Quota holders include those operating for the commercial production of plywood, lumber, posts, and poles. The quota holder must then apply for timber licences which permit him to cut his quota. Timber quotas are on a twenty year, renewable basis.

3. Timber Permits are short term dispositions which convey no long term right beyond the authority to cut a specific stand of timber.[2] Permits are generally issued to authorize small non-commercial operations by private individuals for terms of one year. If applications for permits exceed the available supply, a lottery is used to select the applicant who will receive the permit.

Industry Development

A brief historical account of Alberta's forest industry is given by Teskey and Smyth.[3] Control of natural resources was not given to the province until 1930, before which it was managed by the Dominion Forest Service. Prior to the Canadian Pacific Railways in 1885, the fur trade had been the basis of economic activity. Railroad construction and settlement of the prairies provided a demand for railway ties, timbers, and lumber. Sawmilling grew rapidly from 1900 until the 30's. Because of major markets in Calgary and Edmonton, sawmilling was concentrated near these two centres.

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1. _Ibid._, p. 2.
2. _Ibid._, p. 2.
3. Teskey, A.G. & Smyth, J.H., _op. cit._, p. 11.

In 1954 the first large kraft pulpmill was opened at Hinton (North Western Pulp and Power Limited). Since then a few large sawmills have been built, catering primarily to the export market in the United States. During the same period, plywood manufacturing, fireboard and pressure treating industries developed, as did the numerous small sawmills. In 1973 a second large kraft pulpmill started production (Proctor & Gamble Cellulose Limited).

The Present Industry

Alberta's wood-using industry encompasses both the large, sophisticated plant and the small, rudimentary operation. The industry may be divided into four sections. These are: Sawmills and Planning mills; Pulp and Allied groups; Veneer and Plywood industry; and the Wood Preservation industry.

The 222 Alberta sawmills and planing mills operating in 1972 produced 617,661 thousand board feet of rough sawn lumber of which 580,969 thousand board feet or 94 percent was planed. As the backbone of the province's forest products industry, these activities accounted for 52 percent of gross sales and 54 percent of net sales.[1] Table III-1 reveals the concentration of lumber production in Alberta for 1972. The six largest sawmills in Alberta produced 32.4 percent of the total lumber production. Such a concentration level (under the four firm denotation) would be classified as atomistic. It is also observed that 21.6 percent of the largest mills produce 88.6 percent of the total lumber production. Conversely 62.4 percent of the smallest mills accounted for only 2.2 percent of output.

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1. Ibid., p. 64.

TABLE III-1

CONCENTRATION OF LUMBER PRODUCTION

IN ALBERTA, 1972

Cumulative No. of Mills	Cumulative PER CENT OF MILLS (largest to smallest)	Cumulative Percent of Total Production
6	2.8	32.428
9	4.2	41.941
16	7.5	68.060
28	13.1	81.757
46	21.6	88.610
59	27.7	93.308
69	32.4	95.906
80	37.6	97.768
85	39.9	97.884
91	42.7	97.990
102	47.9	98.688
130	61.0	99.263
146	68.5	99.406
160	75.1	99.749
179	84.0	99.860
185	86.9	99.868
199	93.4	99.930
213	100.0	100.000

Source: _Ibid_., p. 33.

The pulp and allied groups had net sales of nearly 40 million dollars in 1972, ranking second to sawmilling.[1] Its four firms produced kraft pulp, fireborad, construction papers, and tall oil. These products were marketed in a variety of grades, shapes, and sizes both domestically and internationally. Since the majority of products produced by the paper and allied industry group are exported outside Alberta and Canada, the income and employment multipliers generated by secondary processing industries are necessarily low. This results because of the lack of value-added on these exports. However, relatively high wages in the industry do generate significant consumption multipliers in the province.[2] Another feature of this section of the Alberta forest products industry is that its firms sell primarily in international markets that are very price competitive. This fact makes the concentration ratio within Alberta of 100 percent by the largest four firms somewhat irrelevant and misleading.

In 1972 the veneer and plywood industry consisted of three firms. With gross sales of nearly 21 million dollars, this group produced and sold 1,169 million square feet/1/6-inch basis (172,000 square metres/1 millimetre basis) of plywood.[3] This output is distributed equally between the three firms. Canadian markets absorbed all the production with Ontario and Quebec consuming 32 and 30 percent respectively, while

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1. Ibid., p. 74.
2. Ibid., p. 75.
3. Ibid., p. 78.

Alberta consumed 21 percent. The rest of western Canada accounted for 12 percent, and the remaining 6 percent was sold to maritime markets. There were no exports to other countries.

The wood preservation industry consisted of 7 firms, producing 7 percent of forest industry sales in 1972. A wide range of pressure treated products are produced primarily for the Alberta market.[1] This market consumed between 79 and 100 percent of each of the product groups. Remaining western provinces took substantial quantities while eastern Canada purchased nothing. International sales were limited to the United States, consuming some 6 percent of the poles and piling.

Wood Chips

The processing of timber into lumber, plywood and veneer results in the accumulation of residues. Such residues may be processed by chipping into the secondary product of wood chips. Wood residues are chipped for various end uses, and have helped to make marginal operations economically feasible. For the purposes of this study, wood chips shall be defined as: that residue material which is chipped for use as raw material input into the bleached kraft pulping process.

Marketing of these wood chips in Alberta is almost exclusively between sawmills, plywood mills and the two bleached kraft pulpmills in the province. These chips are substitutes for the pulpmills' timber stands as wood inputs for pulp. Wood chips are also produced for other end uses in the province, such as chipboard and livestock bedding, but this is relatively minor.

The specific end use of wood chips requires standardization and

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1. Ibid., p. 78.

grading in order for the usable fibre to be secured in the manufacturing of pulp.[1] The size of the chip is related to the quality required for such end uses. The grading system used by the two bleached kraft pulpmills in Alberta is the Williams Chip Classification System. It incorporates the size of chips, moisture content and amount of fines.[2] The system's requirements are as follows:

Chips sized by screens:	+ 1 1/8"	(Maximum 10%)
	+ 7/8"	(Maximum 30%)
	+ 5/8"	(Maximum 30%)
	+ 3/8"	(Maximum 20%)
	+ 3/16"	(Maximum 7%)
	- 3/16"	(Maximum 5%)

The system allows for one percent bark in the load of chips, and one percent rot. The level of moisture in the chips should be 0.10 percent. By maintaining high quality chip inputs, pulpmills are able to sustain the quality of their pulp.

The marketing of any commodity involves physical exchange between supplier and purchaser. The exchange is carried out using a measurable unit of the commodity. Wood chips are normally measured by Bone Dry Units (BDU). One BDU is 2400 pounds of wood dried to zero percent moisture at 103 degrees Celcius for 24 hours.[3] This widely used

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1. Usable Fibre pertains to the amount of fibre in the wood chips which can be processed into pulp. The minimum length of fibre required is approximately one inch.
2. Fines are normally referred to as any foreign material in the chips.
3. Hanssen, T.B. & Platou, R.S., "Definition of Technical and Economic Terms and Figures Used in the Logs, Wood Chips and Pulp Trade," FAO/NORAD SYMPOSIUM ON PRODUCTION, HANDLING, AND TRANSPORT OF WOOD CHIPS, (July, 1972), p. 13.

measure is quite confusing in as much as it is not directly netted to the fibre content. The fibre content of a unit or number of units (load) depends upon: type of species, basic density, moisture content, type of chipper, size of chips and composition of small and large particles, compaction, method of loading, scantling structure, form of container, height of container, and care in loading.[1]

Every pulpmill has a scale for weighing trucks or railway cars and drying ovens. A typical weight card for a truck load can look as follows:

GROSS WEIGHT	58674 pounds
Weight of Car	11204 pounds
Net Chip Weight	47470 pounds

Weight of Sample	Before Oven	After Oven
Gross	6,510 lb.	5,660 lb.
Tara	4,510 lb.	4,510 lb.
Sample Weight	2,000 lb.	1,150 lb.

Calculations for the value of the unit are then made:

$$\text{Moisture Free Percentage} = \frac{\text{Dry Weight}}{\text{Wet Weight}} \times 100$$

$$= \frac{1{,}150 \times 100}{2{,}000}$$

$$= 57.5\%$$

$$\text{The number of Bone Dry Units} = \frac{\text{Net Chip Weight} \times \text{Moisture Free Percent}}{100 \times 2400}$$

$$= 11.37 \text{ BDU}$$

The supplier and the driver are paid according to the derived number of BDU's.

1. *Ibid.*, p. 11.

The transportation of wood chips in Alberta is accomplished by railway or truck. There are four railways in the province: Canadian National Railway, Canadian Pacific Railway, Northern Alberta Railway, and Alberta Natural Resources Railway. A large number of independent truckers are available in the province. These modes of transportation are exercised through both primary forest products and secondary products. Canadian National Railways supplying wood chips to Hinton use an 880 series car, which will hold 33 BDU per car. Trucks vary from 5 to 7 axles and screened trailers average 28 BDU per load.

Factors affecting the economics of chip transportation are: compaction, price, and loading and unloading times. The percentage of compaction affects the cost of transportation. Within normal limits the greater the amount of compaction, the lower are the costs. The formula used to calculate the amount of compaction is:[1]

$$\text{COMPACTION} = \frac{\text{BDU X 200 X 100}}{\text{Available Cubic Feet}}$$

One hundred percent compaction is defined as one BDU per 200 cubic feet of space.

The price of wood chips is important in the economics of their transportation. The price varies with the pulpmill purchasing the chips. The average price in Alberta for 1977 was approximately 20 dollars per BDU at the sawmill.[2] Wood chips are a low value, bulky commodity, and transportation costs form a large portion of their value.

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1. *Ibid.*, p. 17.
2. This figure was obtained from industry sources.

Loading systems for wood chips in Alberta are: the gravity loading system and the pneumatic loading system. The gravity system utilizes overhead bins or bunkers, and obtains approximately 85 percent compaction.[1] The pneumatic system uses air and blows the chips into the container, either by moving the container along or by a wig-wag which moves back and forth above the container. This system obtains from 105 to 120 percent compaction.[1] The unloading of chips cars or trucks at the pulpmill is achieved with hydraulic lifts. Piles of chips are formed and chips are usually handled from here by front end loader and conveyor belts. Some of the usable fibre may be destroyed before the chips are loaded into a vessel in cutting, chipping and handling.[2]

Alternate Uses

Apart from the use of wood chips as an input into pulping, other uses exist. In southern Alberta, chips are used for livestock bedding. Small chips not suitable for pulping are used for fuel in the steam-generators in the pulpmills and sawmills. Building Products of Canada use some 7,000 BDU's of wood chips as inputs into chipboard at Wabamun.[3] Iko Industries in Calgary utilize some chips at their pulpmill.

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1. Christie, R.G., An Analysis of Chip Handling in the British Columbia Interior, (BSc: Thesis, University of British Columbia, 1967), p. 9.
2. Hanssen, T.B. & Platou, R.S., *op. cit.*, p. 16.
3. This figure was obtained through correspondence with the company.

Research is being carried out to expand the use of wood chips as well as to increase the productivity of the forest resource. Such uses range from filling old strip mines to a source of fuel for the future.[1] Such uses increase the marketability of wood residues and result in the efficient use of the forest resource.

Industry Trends

A study by Paul H. Jones and Associates Limited[2] indicates some possible short term expansion plans for Alberta's forest industry. These possiblilities include;

1) the Simpson Timber Company (Alberta) Limited commitment in the Whitecort area, and

2) the construction of a separate bleached kraft mill by P&G or expansion of the capacity at their existing mill in Grande Prairie.

It is felt that other major initiatives are unlikely in view of the recovery from the recent ression. The commitment made by Simpson will increase the production of wood chips through its sawmills. Their

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1. Research and reports on these alternate uses are available in abundance in the forestry literature. Two examples of these are:
i) Neal, A.W., Formation and Use of Industrial By-Products: A Guide, (London: Business Books Limited, 1974), Chapter 3.
ii) "Wood Chips - key tool to reclaim strip mine land?" Forest Industries, (Volume 102, Number 12, November 1975), p. 39.

2. Paul H. Jones & Associates Limited, Forest Industry Development Consultants, Vancouver, B.C., Alberta Forest Industry Development Prospects, (Prepared for Office of the Deputy Minister of Renewable Resources, Alberta Department of Energy and Natural Resources, December, 1977).

commitment includes plans to construct a large fibre processing plant which will induce the use of residues. P&G's plans would also require additional wood fibre inputs from residues as well as from forest areas.

In view of the use of wood residue chips as presented in Chapter V, it would appear there is a favorable level of profit to be earned. The expansion of P&G's mill, along with the Simpson developments, places an increased demand on the resource. This is offset by the fact that there is a large net annual surplus of coniferous timber in Alberta. This annual surplus is estimated at 215,715,000 cubic feet of coniferous timber.[1] The result of this surplus is that there is not that much pressure exerted on the forest products industry to increase utilization. These short term expansion plans could easily be supported by such a surplus. However, Jones makes an interesting comment in view of this study in that; "only one forest, Grande Prairie, is totally over-committed although other forests have individual units which are over-committed."[2] Such over-commitment places additional pressure on the resource. It could, as well, possibly account for some of P&G's large wood chip purchases from sawmills and plywood and veneer mills.

The major trends in Alberta's forestry sector are expressed by Jones.[3]

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1. Ibid., p. 24.
2. Ibid., p. 25.
3. Ibid., p. 40.

They are as follows;

a) the declining number of small sawmills coupled with an increase in the number of large, high productivity and low manpower mills;
b) a decline in the workforce;
c) increasing amounts of wood chip supplies;
d) better utilization of the resource in the woods and high recoveries of wood fibre at the sawmills; and
e) a general improvement in transportation facilities, especially for roads and trucking.

The implications which these trends have for the industry lie primarily in the utilization of the forest resource. The increase in the larger mills will have adverse effects on local economies due to specialized labor requirements, but will provide increased efficiency and possibly residue chipping facilities. Better utilization of the resource would result from this increase in efficiency. The use of current technology in the recovery of lumber and veneer from the forest would provide a further impetus for increased utilization as larger mills can afford to use these new developments. Improvements in infrastructure will provide better channels through which the physical marketing of wood chips can occur. The report by Jones expresses that; "the impact of these major trends is a steadily reducing surplus of available timber between existing commitments and a relatively fixed level of annual allowable cuts for each forest."[1] In view of these trends and the findings in this study it is important to ensure long run planning for a forest area's best use in terms of efficiency and value-added. The pressure on the efficient productive use of forests is matched with pressure on the preservation for recreational use as well.

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1. Ibid., p. 40.

The results of this study indicate a general trend of an increase in wood residues by the forest products industry in Alberta. A mill residue survey by G. E. Styan[1] indicates that Alberta mills used only 40 percent of their residue for the higher value end product pulp. The study by Jones[2] estimated that approximately one-half of solid wastes from sawmills found a market in local pulpmills as chips. Table III-2 shows the residue utilization for British Columbia and Alberta sawmills.

Table III-2. Residue Utilization for Sawmills and Veneer Mills

MILLS	NUMBER	ANNUAL PRODUCTION	CHIPPABLE MATERIAL (ton/yr.)	SAWDUST AND SHAVINGS (ton/yr.)
Veneer	10	3,000 MM sq.ft.(1/8")	231,000 74% pulping 13% board 12% hog fuel 1% disposal	not significant
Sawmills	73	4,390 MM fbm	3,187,000 93% pulping 1% board 6% disposal	1,844,000 19% pulping 15% hog fuel 1% bedding 65% disposal
Alberta	8 sawmills 1 veneer	213 MM fbm +260 MM sq.ft.(1/8")	154,000 66% pulping 9% board 25% disposal	100,000 5% bedding 95% disposal
British Columbia	65 sawmills 9 veneer	4,177 MM fbm +2,740 MM sq.ft.(1/8")	3,264,000 93% pulping 2% board 1% hog fuel 4% disposal	1,744,000 20% pulping 1% board 16% hog fuel 63% disposal

Source: Styan, G.E., op. cit., p. 7.

1. Styan, G.E., Mill Residue Survey for Western Canada. Information Report VP-X-168, (Fisheries and Environment Canada, Western Forest Products Laboratory, Vancouver, British Columbia, April 1977).
2. Paul, H. Jones and Associates Limited, *op. cit.*, p. 39.

Alberta mills show a 25 percent disposal or wastage of chippable material and 95 percent disposal of sawdust and shavings. This disposal is burned or used as landfill. Jones states that, "a relatively high proportion of Alberta's wood fibre is wasted because of 1) too little integration, and 2) transportation systems and infrastructure preventing its being delivered to points of use."[1]

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1. Ibid., p. 39.

CHAPTER IV

SURVEY METHODS

This chapter presents the methodology incorporated in collecting data for this thesis. It includes all areas from which information was collected.

The data collected for this study are used in the primary analysis in Chapter V. The analysis is carried out using a descriptive case-study approach. The market structure within which the wood chips are marketed is of concern as it determines the pricing policy of the pulpmills. The geographic location of sawmills, the costs of transportation, and the resulting price affects the utilization of wood chips. This method of analysis describes such relationships which exist in the marketing of wood chips in Alberta.

Questionnaires

A questionnaire was set up to procure the primary data for this analysis. The questions were organized to obtain both numerical data and an understanding of each producer's situation.[1] It was kept as short as possible to minimize inconvenience to the sawmill and plywood mill's operations, allowing the greatest chance for response. The questionnaire received the endorsement of Mr. Arden Rytz, Secretary-Manager of the Alberta Forest Products Association.[2]

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1. A copy of the questionnaire and the covering letter is contained in Appendix A.
2. A copy of Mr. Arden Rytz's letter is contained in Appendix B.

In October 1976, the questionnaire was mailed out to 27 mills.[1] The majority of these were sawmills with the remainder being plywood mills. The questionnaire was sent to all mills producing more than five million board feet of lumber annually as it was felt that economies of scale resulted in economically infeasible chipping operations from mills smaller than in this sample. As well, no smaller mills were known to supply chips. Two weeks after the initial questionnaire was sent out a follow-up letter was mailed.

The response to the questionnaire is presented in Table IV-1. Of the questionnaires sent out, one was returned unopened and three were returned unanswered.[2] This reduced the effective mailout sample of 23. The total number of questionnaires returned, usable, was 16, giving a response rate of 70 percent.

TABLE IV-1

QUESTIONNAIRE RESPONSE

	Number
Total Questionnaires Mailed	27
Questionnaire Returned Unopened	1
Questionnaires Returned Unanswered	3
Questionnaires Returned Answered	16
Total Usable Questionnaires	16

1. The location and size of mills for the study was obtained from: Teskey, A.G. & Smyth, J.H., A Directory of Primary Wood-Using Industries in West-Central Canada, 1973, Information Report NOR-X-83, (Northern Forest Research Centre, Edmonton, May, 1974).
2. These resulted because the firms had gone out of business.

Results were tabulated and the responses to each question were compared.[1] Comparisons were made on a per unit (Bone Dry Unit) basis in order to establish an average response. Any information on questionnaires which was incomplete or inconsistent with other mills, was corrected by contact with the mill. This insured consistency for all answers.

The bias in the answers was tested by observation of the size of mills answering the questionnaires. Of the mills returning the questionnaire, the average yearly production was 24.34 million board feet. Of those not returning the quesitonnaire the average yearly production was 9.97 million board feet. The information collected was therefore obtained from the largest mills in the province which produce a large portion of those chips marketed in Alberta.

The data collected were viewed in light of a number of discussions with producers which served as a check on the reliability of the results. These interviews also provided some insight into the forest products industry's views on wood residue utilization.

Other Sources

A large part of the data on transportation cost was obtained through the Alberta Government's Department of Transportation in Edmonton. These include rail freight rates and truck operating cost estimates.

Other contacts were made through letters and over the phone, providing further information and feedback.

1.. Tabulation of results and other calculations are given in Chapter V.

CHAPTER V

CASE STUDIES: COMPARATIVE ANALYSIS

The direct goals for a marketing system are 1) to provide efficient and economical services and ownership transfers in the movement of commodities from producer to consumer, an 2) to provide an effective and efficient price-making mechanism.[1] Such goals help our economic system to approach more efficient levels of operation. In the case of wood chips, efficiency depends upon the pricing structure used by the pulp mills. This chapter purports to explain the efficiency of current pricing policies with respect to wood chip utilization.

CASE ONE: PROCTOR AND GAMBLE CELLULOSE LIMITED

Proctor and Gamble Cellulose Limited (P&G), located ten miles south south east of Grande Prairie, began production in August, 1973. P&G operate under a Forest Management Agreement with the province, and the current net annual allowable cut (AAC) from their forest area is estimated at 488,000 cords.[2] Primary product is bleached kraft pulp of which 260,000 tons are produced annually. The company also produces several thousand tons of secondary or by-products such as tall oil and turpentine.

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1. Bressler, R. G. & King, R. A., Markets, Prices and Interregional Trade, (John Wiley & Sons, Inc., 1970), p. vii.
2. This value reflects the level required to provide a continuous flow of products under a sustained yield policy (Chapter III). This estimate was obtained from the Department of Alberta Energy and Natural Resources for the 1976-77 year. It is equivalent to 4.15 X 10^7 cubic feet of solid wood.

At the outset of production, the company depended mainly on the harvest of its forest management agreement area to supply wood fibre, with approximately 10 percent of this input purchased from sawmill residues. Since initial production, the sources of wood fibre inputs has changed to 50 percent from forest management agreement areas, and 50 percent from sawmill chips of other companies. The rationality of this change is assumed to be a result of two factors: 1) the increase in productive capacity of the pulpmill, which requires larger volumes of fibre inputs; and 2) the increasing economic viability of wood residue use from sawmills, and a change in attitude towards resource utilization.

Table V-1 summarizes the flows, volumes, and costs of wood chip purchases by P&G.[1] Sawmills and plywood mills supplying chips were obtained from a questionnaire, and are numbered to respect the confidentiality of the information.[2] The volume of wood chips produced by the six mills in the sample, totals 169,659 Bone Dry Units (BDU) annually and represents 67.86 percent of P&G's annual purchases of 250,000 BDU. The remaining 80,341 BDU of chips is accounted for from Alberta mills not answering the questionnaire, and wood chip purchases from British Columbia.[3]

1. See Chapter IV for description of data procurement.
2. All figures in Table V-1 have been treated by adding or subtracting a dummy value to each variable so that mills can not be identified. The dummy value in each case was selected so that important variables are unbiased estimates of true values. For example, transport costs per BDU are unbiased estimates of real transport costs.
3. The response rate from the questionnaires as reported in Chapter IV was approximately 70 percent, and provided information from the larger mills. The questionnaire was conducted under the assumption that Alberta was a closed market with respect to wood chips and therefore did not include mills in British Columbia, however; chips were purchased from British Columbia during the period of the study.

Supplier	Annual Prod. MMFBM	Annual Chip Output BDU	Chip Output Per MFBM	AVG Number BDU Per Load	Return Dist. To P&G Miles	Variable Truck Costs Per Mile	Fixed Costs Per Mile Truck	Total Cost/ Mile Truck	Total Trip Cost 2-Way Truck	Trip Cost Per BDU	Terminal Cost/ BDU	Total Trans-port Cost/ BDU	Price FOB Saw-Mill	Trans-port cost as % of Price
						DOLLARS								
1	30	8,000	0.30	28	496	0.36	0.43	0.79	391.84	13.99	1.30	15.29	20.00	76.45
2	65	45,550	0.67	25	20	0.43	0.43	0.86	17.20	0.69	1.30	1.99	25.00	7.96
3	32.25	18,059	0.56	25	20	0.43	0.43	0.86	17.20	0.69	1.30	1.99	25.00	7.96
4	27.5	11,800	0.43	30	456	0.36	0.43	0.79	360.24	12.00	1.30	13.30	20.00	66.50
5	25	16,250	0.65	30	250	0.36	0.43	0.79	197.50	6.58	1.30	7.88	20.00	39.40
6	100	70,000	0.70	30	320	0.36	0.43	0.79	252.80	8.43	1.30	9.73	20.00	48.65

TABLE V-1: WOOD CHIP PURCHASES
FLOWS, VOLUMES AND COSTS

PROCTOR & GAMBLE CELLULOSE LIMITED

The quantities of chips supplied to P&G varied per sawmill from 8,000 to 70,000 BDU annually, and averaged 28,277 BDU. The output of wood chips per thousand foot board measure (MFBM) from these mills ranged from 0.30 to 0.70, and increased directly with greater chip output for each mill. The differences in chipper types, log sizes, and lumber products in mill production could possibly account for some of the variation.

The pricing system effected by P&G is based on payment for wood chips at the sawmill (F.O.B. sawmill). The price paid to the supplier plus the freight costs of the chips is a raw material wood fibre input cost to the pulpmill. The price is selected so that the overall level of cost encourages the use of residues, but cost is not dependent upon distance from mills because of uniform pricing. Graph V-1 reflects the price paid per BDU of wood chips to suppliers at various distances. The observed relationship between F.O.B. price and distance to P&G is constant or uniform. The prices paid to wood chips suppliers are established under a contract, which contain some provision for inflationary pressures on suppliers' costs.[1]

All of the wood chips purchased by P&G are transported by truck. Table V-1 summarizes the distances and costs of hauling chips by truck.[2] The average number of BDU per load was 28. Because of the specialized type of trailer required for chips, there is no back-haul,

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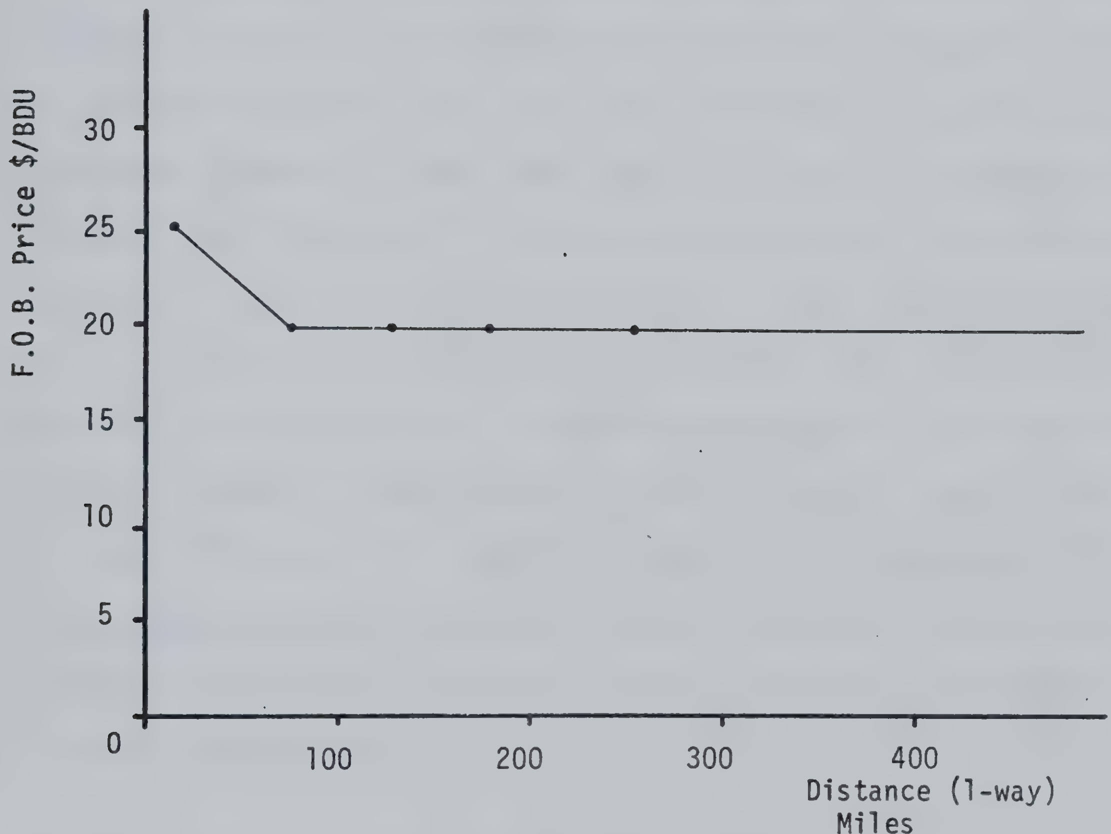
1. According to Fred McDougal, Deputy Minister, Renewable Resources, Alberta Department of Energy and Natural Resources, "Chip prices in Alberta are geared under the contracts, to move annually with the inflation." This was noted in an article by Bill Roger, <u>There's a Boom Coming</u>, B.C. Lumberman, (February, 1977), p. 32.
2. Variable and fixed costs for trucks were obtained from; Ashtakala, Dr. Bala, <u>Alberta Road User Costs: Update 1976</u>, (Alberta Transport, Transportation Planning and Research, January, 1977). See Appendix C for calculations and assumptions.



GRAPH V-1

PRICE PAID F.O.B. MILL TO SUPPLIERS
AT VARIOUS DISTANCES (P&G)

UNIFORM PRICING

which increases transport costs. Fixed costs remained constant for long and short hauls while variable costs per mile were 19.4 percent higher for short hauls. A terminal cost of one dollar and thirty cents per BDU was assumed for loading and unloading. The per unit transport costs were predictably lower for short hauls and varied with respect to both distance and quantity of chips.

Graph V-2 plots transfer costs per BDU against distance of haul (return). Transport costs increase with distance at a constant rate. The transport costs for truck mode were extrapolated to approximate a break-even distance for wood chips supplied to P&G. The break-even distance shown on Graph V-2, is 592 miles return trip. This value was obtained by using values from Table V-1 and calculating transport costs for return distances desired.[1] Industry sources approximate the cost per BDU of chips from company timber at 38.00 dollars. The return trip cost for 592 miles is 18.00 dollars per BDU. Graph V-1 shows a price of 20.00 dollars per BDU freight-on-board (F.O.B.) the sawmill for mills greater than ten one-way miles. Therefore, at a return distance of 592 miles, the cost of acquiring sawmill chips equals the cost of chips from company quotas.

CASE TWO: NORTH WESTERN PULP AND POWER LIMITED

North Western Pulp and Power Limited (NWPP) established the first pulpmill in the province at Hinton, starting production in 1954. NWPP operate under a Forest Management Agreement with the province, and the current net annual allowable cut (AAC) from their forest area is

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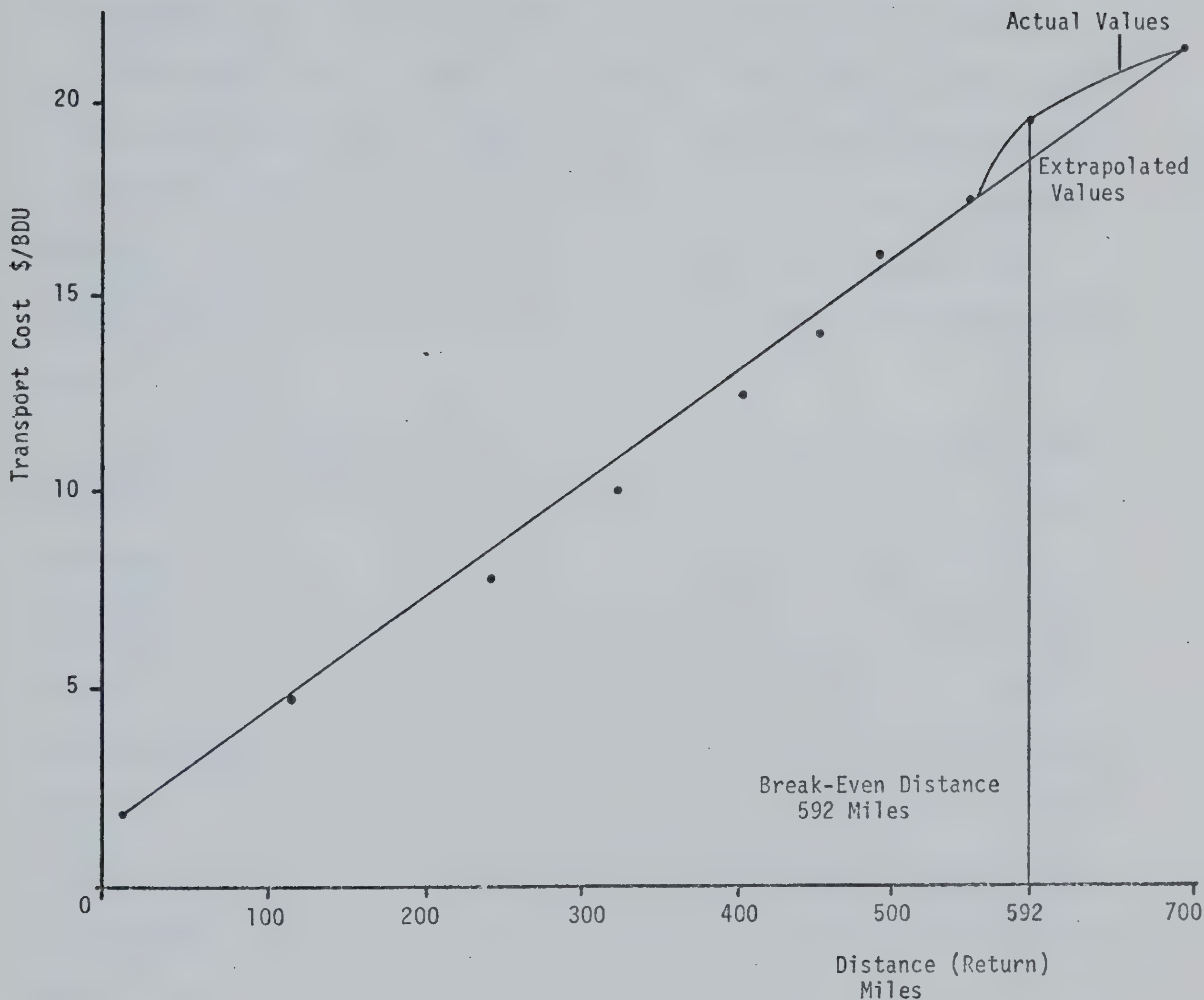
1. For assumptions and calculation of the break-even distance, see Appendix C.



GRAPH V-2

TRANSPORT COSTS TO DISTANCE OF HAUL (TRUCK)

estimated at 357,000 units.[1] Current annual production (1976-77) of the mill is 198,000 tons of bleached kraft pulp. Several tons of by-products such as turpentine and tall oil are produced as well.

When NWPP began production, they obtained most of their wood fibre inputs from company timber stands. A small portion was obtained from wood residues and from private lands. Since initial production, NWPP has altered its raw material fibre inputs to 77 percent from timber stands, 11.23 percent from private land, and 11.23 percent from sawmill chips.

Table V-2 summarizes the flows, volumes and cost of wood chip purchases by NWPP. Sawmills supplying chips were obtained from a questionnaire and are numbered to respect the confidentiality of the information.[2] The volume of wood chips produced by the 4 mills totals 46,180 BDU annually and represents approximately 90 percent of NWPP's annual purchases of 50,000 BDU. Thirty-four percent of these wood chips are supplied from the company's sawmill at Hinton. The wood chips purchased from sawmills represent 11.23 percent of the total 445,000 BDU input into the pulpmill. An additional 11.23 percent comes from private land owners and government land.

The pricing system effected by NWPP is based on payment for wood chips F.O.B. the sawmill. The price paid to the supplier plus the freight costs of the chips is the raw material wood fibre input cost

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1. As for P&G, this value reflects the level required to provide a continuous flow of products under a sustained yield policy (Chapter III). The estimate was obtained from Alberta Energy and Natural Resources for the 1976-77 year. This is equivalent to 3.57 x 10^7 cubic feet of wood.
2. All figures in Table V-2 have been treated by adding or subtracting a dummy value to each variable so that mills can not be identified. The dummy value in each case was selected so that important variables are unbiased estimates of true values.

Supplier	Annual Production MMFBM	Annual Chip Output BDU	Chip Output Per MFBM	Average Number BDU Per Rail Car Load	Rail Miles To Pulpmill	Rate In Cents Per BDU[1]	Total Trip Cost	Per BDU	Price FOB Saw-Mill	Trans-Port Cost As % of Price	Total Cost Per BDU at Pulpmill
							-------DOLLARS	--------	--------		DOLLARS
1	34	16,000	0.60	33	251	1846	609.18	18.46	16.75	110.21	35.21
2	50	17,000	0.34								
3	27	10,180	0.50	32	282	1951	624.32	19.51	20.00	97.55	39.51
4		3,000		25	128 (2-way truck)		101.12	4.04	24.00	16.83	28.04

TABLE V-2: WOOD CHIP PURCHASES
FLOWS, VOLUMES AND COSTS

NORTH WESTERN PULP & POWER LIMITED

1. These rates are published and were effective January 1, 1976 CNR Issued by Miss F. Rupperthal, Chief of Tarriff Bureau, 123 Main Street, Winnipeg, Manitoba.

to the pulpmill. The price is selected so that the cost at the pulpmill is identical, regardless of distance. Graph V-3 reflects the price paid per BDU of wood chips to suppliers at various distances.[1] The relationship between F.O.B. price and distance illustrates straight-line pricing; as distance increases, price decreases. The F.O.B. price at the sawmill is determined by subtracting the per unit transport costs form the cost of obtaining one BDU from company timber stands. At an estimated cost of between 36 to 38 dollars per BDU for fibre harvested from the company's timber stands, the F.O.B. price at the sawmill would be zero when transport costs reached 36 to 38 dollars per BDU.[2]

Approximately 6 percent of wood chips purchased by NWPP are transported by truck. The remaining 94 percent are transported by rail. The rail rates per BDU presented in Table V-2, are published rates, and therefore may not reflect actual costs incurred by NWPP in transporting wood chips.[3] This transportation system used by NWPP utilizes the services of 12 - 880 series rail cars, and problems may arise in turn around time with the cars, resulting in delays.[4] Sawmills require one or two cars regularly to load as chips are produced from

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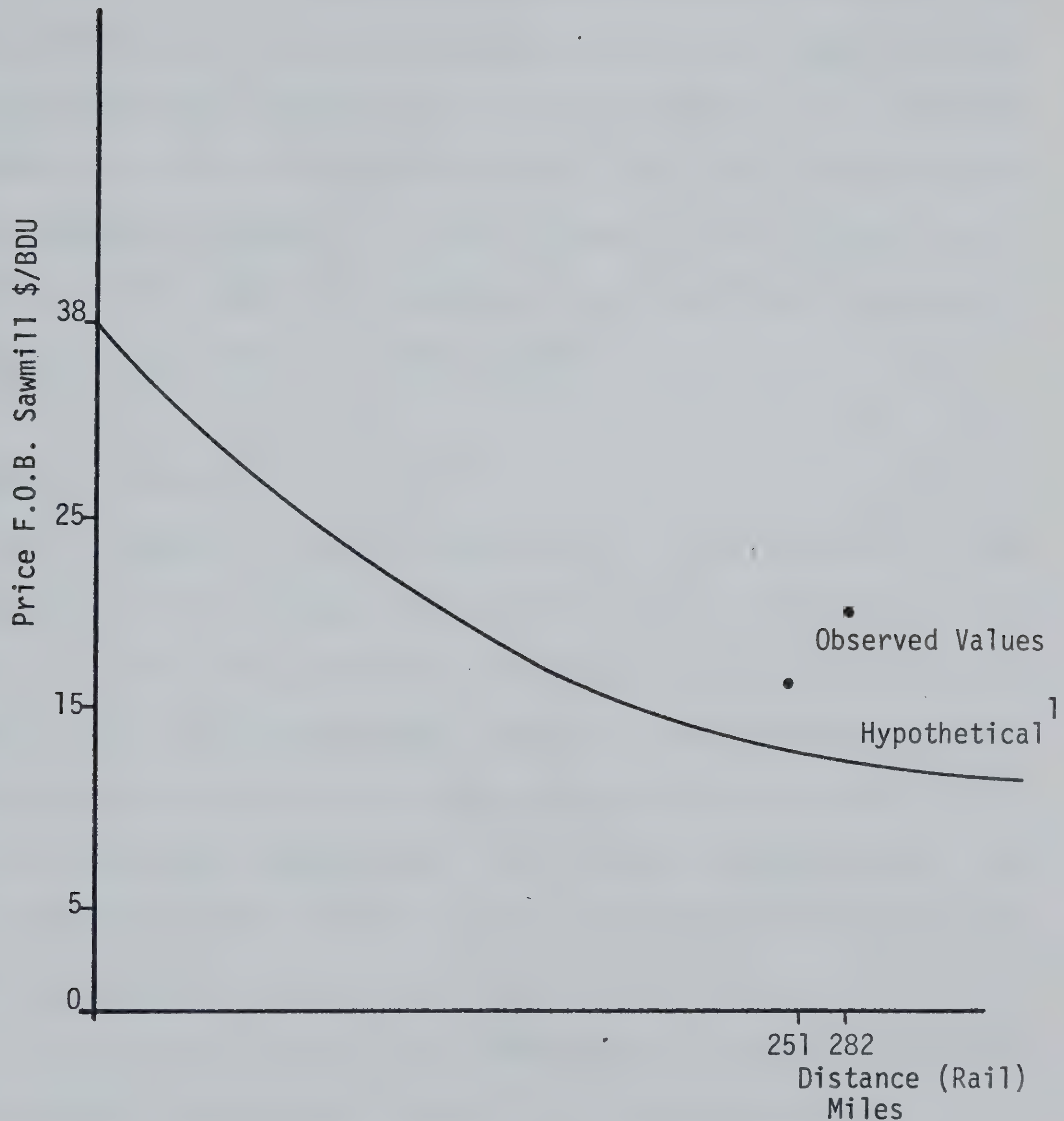
1. Due to insufficient data from questionnaires, the graph was estimated from discussions with NWPP, which revealed a straight-line system.
2. This estimate was obtained from discussions with NWPP. With respect to these purchases, section 20 of the Forest Management Agreement between the Government of Alberta and NWPP (O.C. 1647/68) states "... if these logs and other forest materials...(c) are offered for sale to it at other prices competitive with the average costs experienced by the Company in delivering logs or other forest materials,..." It is therefore evident that there is no obligation to pay a price in excess of their costs.
3. These rates were effective January 1, 1976 for Canadian National Railways. They are issued by the Tariff Bureau, Winnipeg. Freight rates between parties may be negotiated.
4. This information was obtained from industry sources.



GRAPH V-3

PRICE PAID F.O.B. MILL
TO SUPPLIERS AT VARIOUS DISTANCES
(NWPP - HYPOTHETICAL)

1. This curve was estimated by deducting published rail rates from the cost of wood chips from company forest areas ($38/BDU). The published rates do not necessarily reflect negotiated rate.

their operation. Actual costs may vary with the loading method used, as varying degrees of compaction are obtained.[1]

Graph V-4 plots transport cost to distance of haul via rail. The graph reveals that as distance increases, the cost per BDU increases but levels off where economies of scale are reached. This general illustration reveals the economies of scale for rail transport over longer distances; however, for the volumes of chips and distances recorded in this study, such economies of scale were not evident over the per BDU truck costs calculated for P&G.

COMPARATIVE ANALYSIS

The two pulpmills in this study face a similar market in the procurement of wood residues for pulp fibre inputs. The differences lie in the price and transport mechanisms incorporated by each pulpmill. The two pricing systems employed in the marketing of wood chips by P&G and NWPP are the uniform pricing system and the straight line pricing system respectively. This analysis centres around the use of these systems by the two pulpmills and looks at the marginal costs and revenues in terms of wood chip utilization.

The collection of data; using questionnaires, personal interviews, and published information; resulted in the preceding cases. This provided the pricing systems in effect and transport costs. Data on chipping costs for the sawmills were highly variable, and as a

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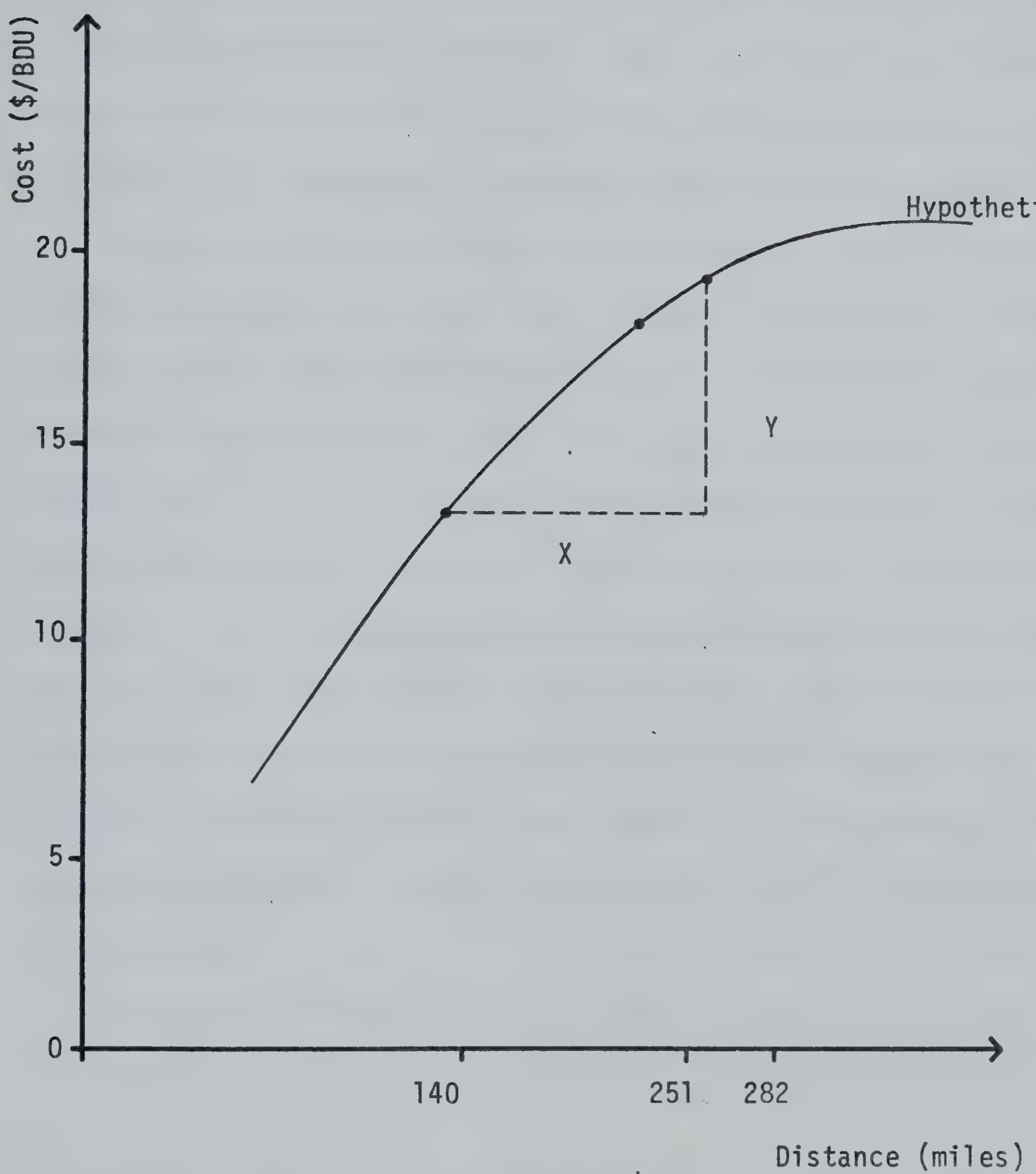
1. Compaction of wood chips in loading is discussed in Chapter III.



GRAPH V-4

TRANSPORT COST TO DISTANCE OF HAUL
(RAIL)

result no comparisons were possible.[1] The useability of the data is limited in that it is impossible to derive statistical verifications from the small numbers in the questionnaire. This discussion therefore serves as deterministic treatment of the data in testing the hypothesis. Comparisons are based on transport costs and prices, and reflect the relative efficiency of the two pulpmills with respect to the utilization of wood chips from sawmill and plywood and veneer mill residues.

Comparison of these two pricing systems is carried out under the following assumptions. The first is that the pulpmills are profit maximizers and react predictably to economic conditions, given their relative degree of market power. The second assumption is that all chips are of uniform quality, resulting in no distinction or differentiation of chips apart from the geographic location of the supplier. The third assumption is that sawmills are price takers to the extent that they require a minimum price to cover the cost of the chipping and return on investment. The fourth assumption is that chipping costs are uniform for each sawmill. Cost estimates from the questionnaire were so highly variable, that no trend could be established.

The effect of these pricing systems on wood chip utilization may be illustrated by the following theoretical concepts. Economic rent

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1. The chipping costs received from the questionnaires ranged from \$0.99 to \$16.50 per BDU. A follow up by phone interviews to very high or low estimators discovered that the mill's costs were calculated on a different basis and, in some cases, were not clearly separated out from other mill costs.

is defined by Barlowe as "the surplus of income above the minimum supply price to bring a factor into production".[1] This concept of rent may be broadened to include any input which earns a surplus. This surplus is defined by Baumol as "any payment in excess of the amount necessary to have the input in question supplied".[2] Graph V-5 shows the total resources cost of output y*, as the area under the marginal cost (MC) curve, Oy* DC. Baumol states that "the shaded area, CDE is the producer's rent or surplus which goes to the suppliers of a firm's productive resources".[3] This distribution of of rent forms the basis of this analysis comparing uniform and straight line pricing systems.

Graph V-6 shows how the economic rent may be transferred to flatten the marginal revenue (MR) curve to a horizontal position. This transfer of extra-profitability (rent) would increase the economic break-even distance under the uniform pricing system, and may alter the straight line pricing system towards a uniform system. This transfer of economic rent in NWPP's case would depend upon the degree of rent or surplus obtained from purchased wood chips. The larger the economic rent available, the greater the possibilities for transferring to far mills in terms of transport costs.

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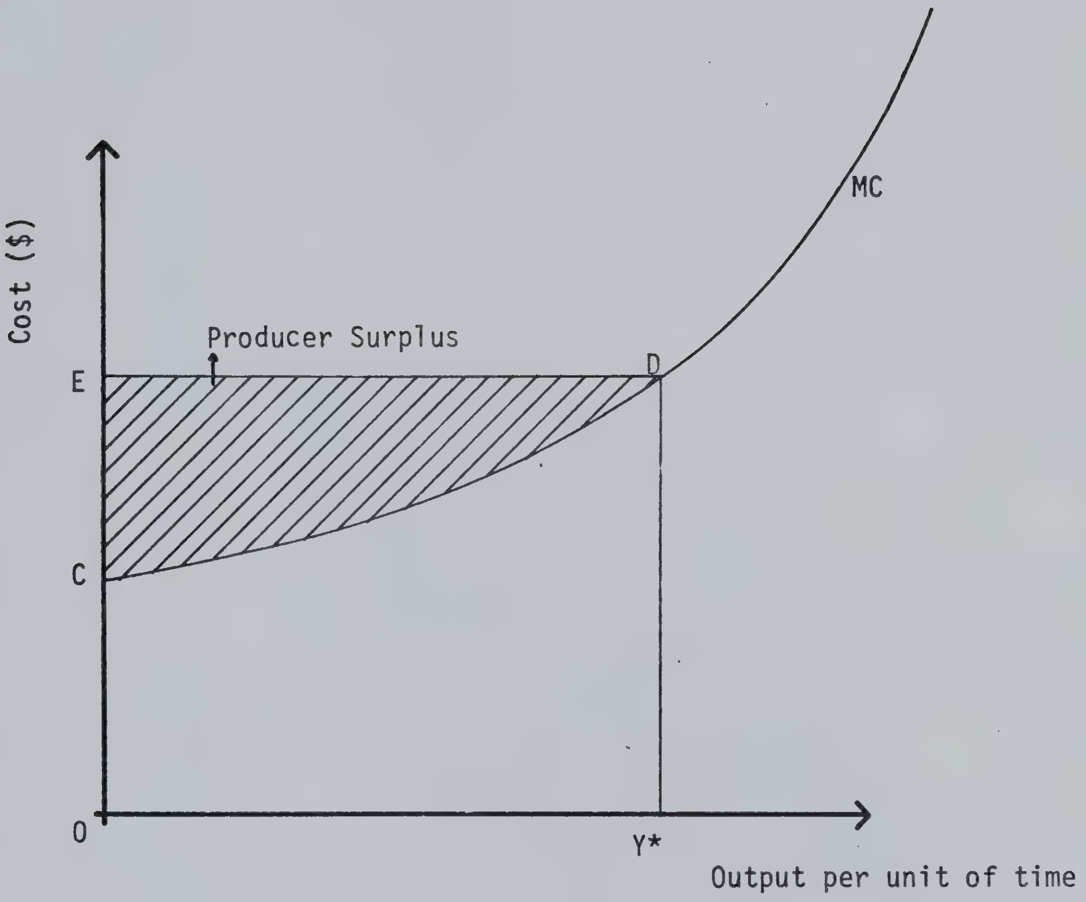
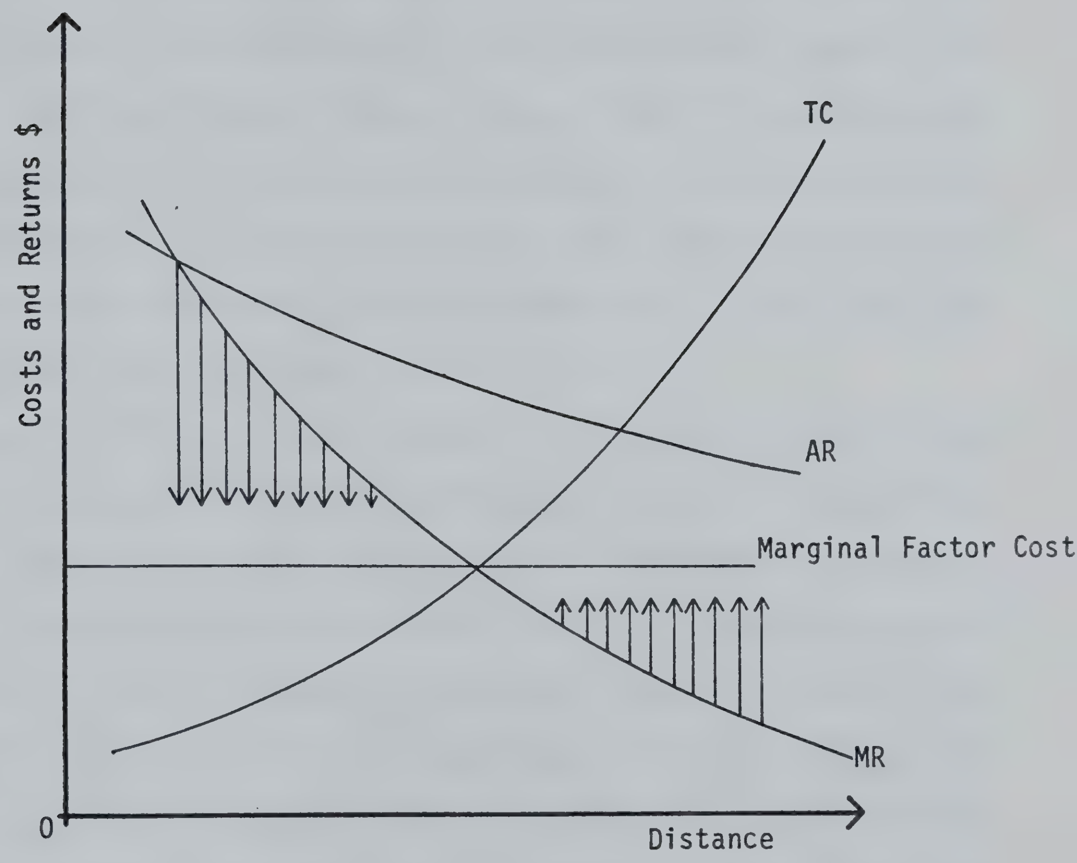
1. Barlowe, R., op. cit., p. 158.
2. Baumol, W.J., Economic Theory and Operations Analysis, 4th ed. (Englewood Cliffs, N.J.: Prentice-Hall Inc., 1977), p. 593.
3. Ibid., p. 595. The area CDE, producer surplus, together with consumer surplus (on the output side), is often taken as the appropriate maximum in the analysis of welfare economics and pareto-optimality (See Chapter II).



GRAPH V-5

PRODUCER SURPLUS

Source: Baumol, W.J., op. cit., p. 594.



GRAPH V-6

TRANSFER OF ECONOMIC RENT

The transfer of producer surplus or economic rent is subject to practical limitations. These are 1) the ability of the pulpmill to alter prices, 2) the capacity of the pulpmill to absorb increased supplies of wood chips from sawmills brought into the economic break-even distance,[1] 3) the attitudes of sawmillers towards residue chipping), and 4) the distance from the furthest supplying sawmill to the next closest potential supplier. This distance may require too great a price drop to cover transport costs. Such a large price cut would bring the price level below the marginal cost of producing a unit of chips. Also, the economics of rail transportation may restrict a clear cut transfer of rent between mills, in that it is not as flexible a form of transport as trucking.

Graph V-7 plots distance and price, illustrating the uniform pricing structure and the distance chips may be hauled. The marginal revenue (MR) curve reflects the revenue to the sawmill per BDU of chips. The marginal cost (MC) curve is the per unit costs of chips to the sawmills. Xo represents the break-even distance chips will be transported given the uniform pricing system used by P&G. Under this system, lowering the price of chips could result in the economic break-even distance being increased to bring additional chips into productive use. This is illustrated in Graph V-7 by the dotted lines and arrows indicating the change in MR and MC curves. Such a manipulation in price can occur until price equates to the marginal

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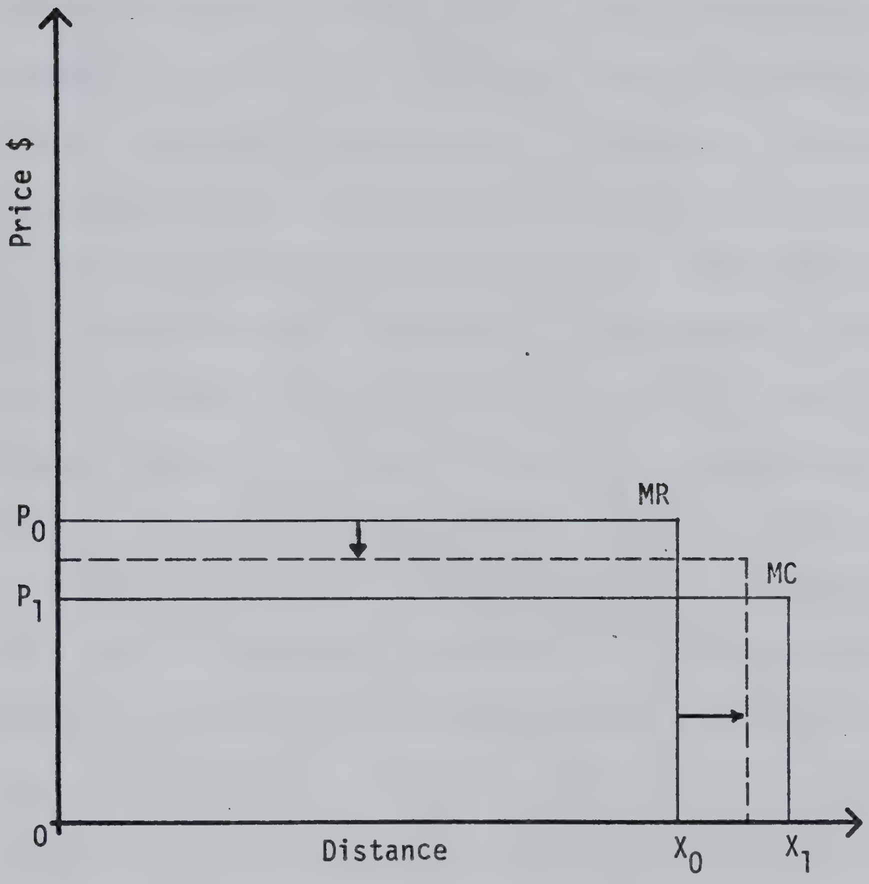
1. The attitude of the pulpmill purchase as to the reliability of the supply is a major component here. Further, they can not vary their own cut quickly either up or down, by 10% within any one year. Larger changes are possible with at least 1-2 years notice.

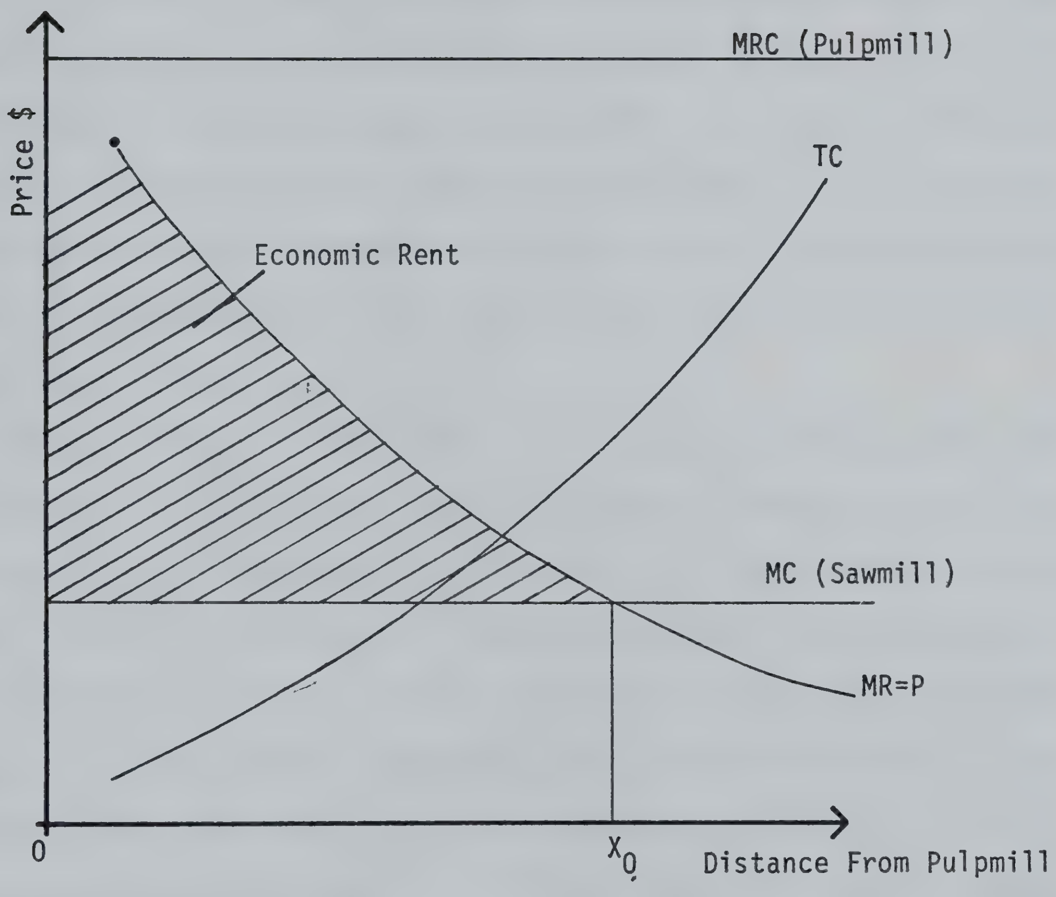


GRAPH V-7

UNIFORM PRICE AND
DISTANCE OF HAUL

cost of the sawmill. This is reflected by points P_1 and X_1 on the critical and horizontal axis respectively. Equating price to marginal cost would not occur fully under the present industry system, as the sawmills require a certain percentage of profit to chip residues. It does, however, show how price may be altered to affect the increased production and use of wood chips. Such manipulation involves the transfer of economic rent or producer surplus from near mills to far mills. This would be a trade-off of revenue for increased utilization. The forgone revenue (lower price) is transferred to transport costs to increase the economic break-even distance. This could also be achieved by transferring some of the profit of the pulpmill, in the form of low cost raw material inputs, to the far sawmills; thus increasing wood chip utilization. In view of this, it is apparent that the uniform pricing system discriminates in favor of distant mills.

Graph V-8 illustrates the straight line pricing system used by NWPP. MRC is the marginal resource cost of the wood chip inputs per BDU to the pulpmill. It may also be described as the price paid for chips at the sawmill. The MRC is constant in this case, and equates to the cost of wood chips per BDU from company timber. Transport costs (TC) vary directly with distance, and the marginal cost (MC) and marginal revenue (MR) curves reflect the per BDU costs and revenues respectively. MC, as in Graph V-7 is constant, and MR or F.O.B. price at the sawmill reflects straight line pricing in that price declines as distance from the pulpmill increases. From Graph V-8, it is observed that sawmills near the pulpmill enjoy an economic rent from location. The shaded portion under the marginal revenue curve is the



GRAPH V-8

STAIGHT-LINE PRICING
AND ECONOMIC RENT

economic rent, which declines with price. Under this pricing system, the economic rent is not transferred from near mills to far mills. The resulting break-even distance here is Xo, where MC = MR. A method of increasing the economic break-even distance is to raise the overall price. This price would be restricted by the marginal resource cost to the pulpmill in that the highest price will be limited by the highest cost which the pulpmill will be prepared to incur for the wood fibre inputs. As stated in the case for NWPP, this cost is the cost per BDU of chips from their forest management area. In this context one might note that if transport costs are reduced, the cost limitations are less restrictive and hence would result in an extension of the break-even distance.

Graph V-9 and V-10 plot the marginal revenue, marginal costs, and prices for the two pricing systems. The marginal revenue for chips is the same per unit regardless of its source.[1] The differences in the two occur in the price and marginal cost curves. Under uniform pricing, the marginal cost curve is steeper, revealing that the cost increased faster than the flatter marginal cost curve under straight line pricing. The slope of the price line reflects the price to distance relationship for each system. It is the difference in prices which accounts for the marginal costs to the pulpmill, and in turn where the economic break-even distance lies.

The rational behind the two pricing systems is the profit maximizing goals of the pulpmills. Graph V-11 plots the price (cost) of wood chips per BDU from wood residues against the price (cost) per

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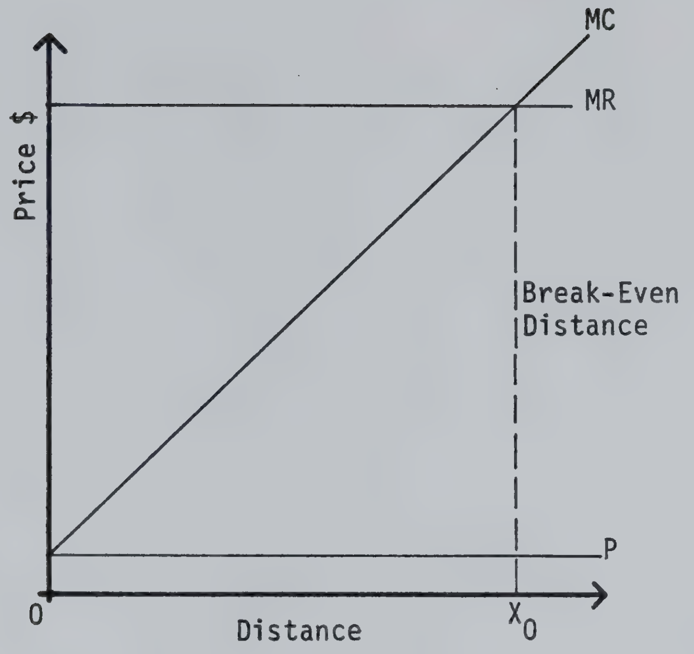
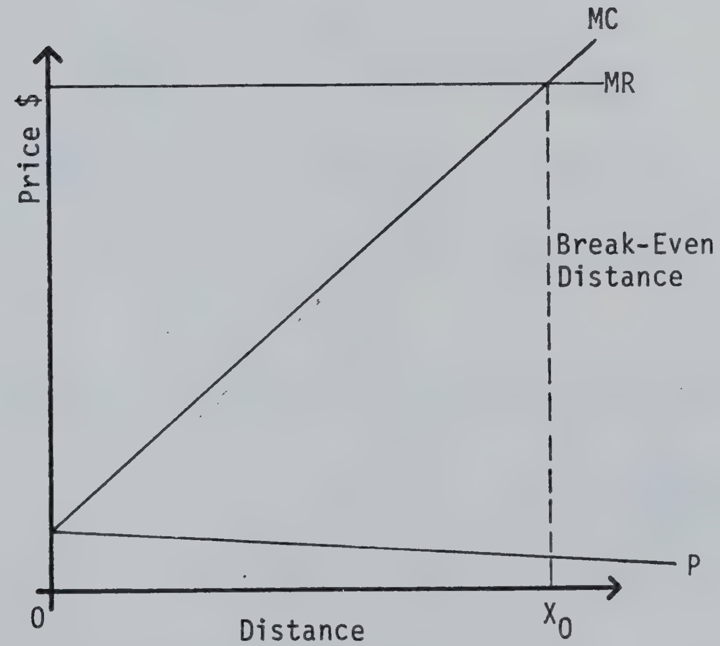
1. This is based on the assumption that both pulpmills receive the same price per ton of pulp produced.



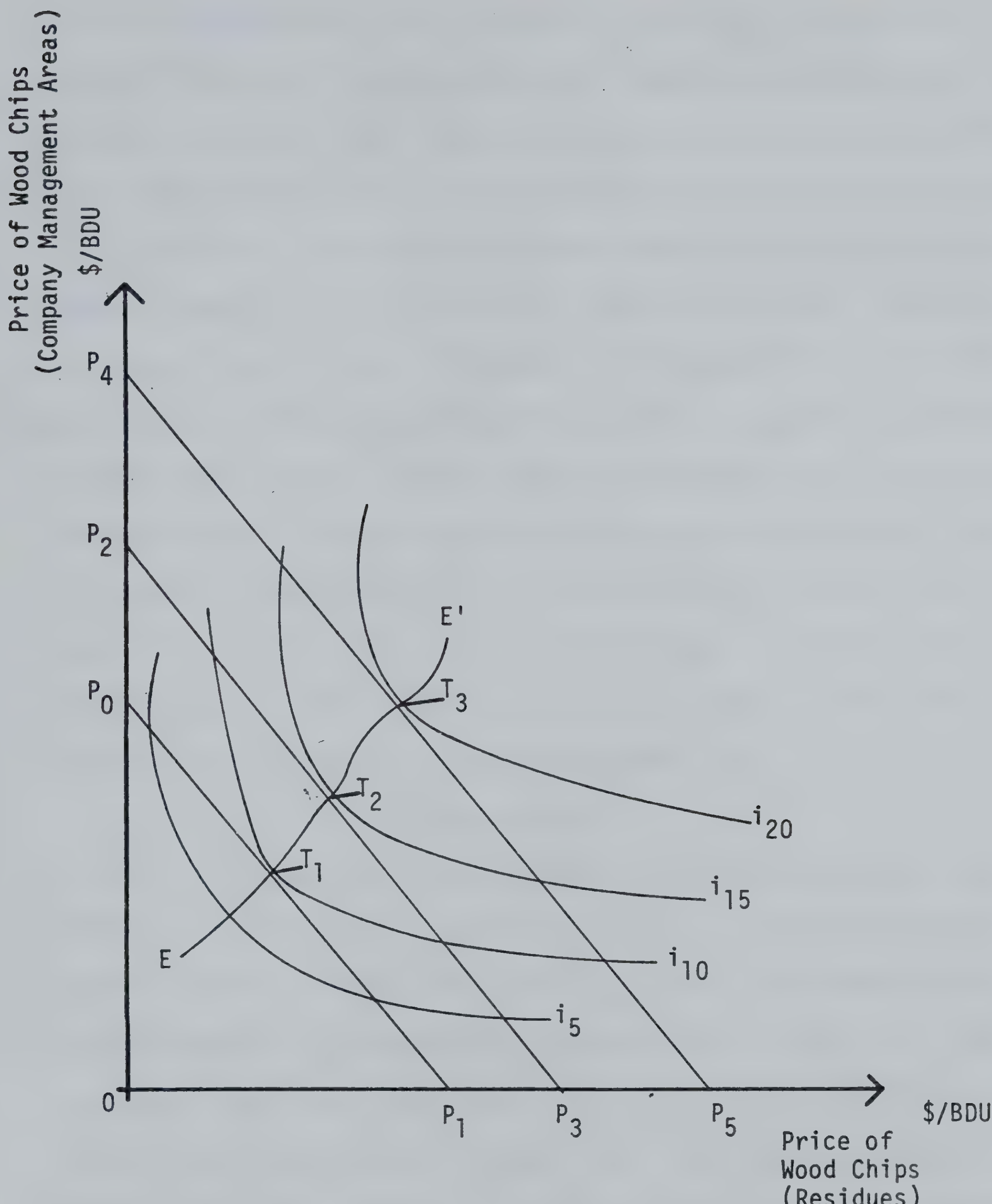
GRAPH V-9

PRICE AND MARGINAL COST CURVES:
UNIFORM PRICING



GRAPH V-10

PRICE AND MARGINAL COST CURVES:
STRAIGHT-LINE PRICING



GRAPH V-11

PRODUCTION INDIFFERENCE CURVES:
THE OPTIMALITY RULE

BDU from company forest areas. The price line (P_0P_1) is the line of constant expenditure, and represents all combinations of wood chips from sawmills and company held forest areas which can be purchased for a fixed sum of money. It is in the interest of the profit maximizing firm to obtain as high a level of production as possible from that level of expenditure. The production indifference curves (designated as i_5, i_{10}, i_{15}, and i_{20}) are defined for the general case, by Baumol as "a locus of input combinations all of which are capable of producing the same output level."[1] Optimal input combinations occur at points of tangency between a production indifference curve and a price line. This geometric representation is the optimality rule as stated by Baumol; "an optimal combination of any two inputs, I and J, requires that the ratio of their marginal products be equal to the ratio of their prices."[2] This ratio may be represented as

$$MP_i/MP_j = P_i/P_j$$

Curve EE' on Graph V-11 is the company's expansion path, which illustrates how the firm's optimal input combination will vary as the company expands expenditure for wood chip inputs. The price paid for wood chip inputs by the pulpmills reflects their costs. As profit maximizers, they will seek the optimality condition or point of tangency as illustrated in Graph V-11. As oligopsonists, the pulpmills are able to effect a certain amount of control on input prices, particularly from sawmills and plywood and veneer mills. Their costs from company forest area wood chips depend upon the efficiency of their harvesting methods used. Because of this relative control on input price, they are able to effect a change in price and

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1. Baumol, W.J., op. cit., p. 282.
2. Ibid., p. 284.

and therefore the slope of the price line. Such control allows the optimality condition to be met easily and, because of the change in slope of the price line, allows a greater level of input and hence greater level of output for the same expenditure. It is interesting to note the relative level of wood chip inputs from company forest areas and from wood residues between P&G and NWPP. They are approximately 50 to 50 percent even split for P&G and 88 to 12 percent for NWPP. The practice of transferring rent to far mills through uniform pricing suggests that greater proportions of wood chips could be purchased. This is in accord with observed higher proportions of wood chips utilized by P&G, using a uniform pricing system.

RESULTS

The pricing systems effected by the two pulpmills result in different levels of wood chip utilization. The profit-maximizing motives of the pulpmills seeks the optimality rule; achieving a combination of wood chips from company forest areas and from wood residues, where the ratio of their MP's equals ratio of their prices. Other factors such as an increased concern for the efficient use of our resources, and the forest management agreements between the pulpmills and the province, affect the marketing of wood chips from sawmill and plywood and veneer mill residues to input as pulp fibre.

As wood chips are a secondary or by-product of the sawmill industry, they have developed around the industry structure which developed from demand for pulp, lumber, and plywood products. In terms of the use of wood chips as input into pulp, the market is an

oligopsony, with the existance of only a few buyers. The pricing policies of the two pulpmills is a result of this imperfect market structure. This structure stems from the location of pulpmills, sawmills and plywood mills with respect to each other.

The primary hypothesis set forth in Chapter I was;

> The market structure in existance for the procurement of wood chips is inefficient with respect to their utilization, and therefore restricts the potential flow of wood chips as input into pulp production.

This imperfect market structure results in a certain pricing behavior of the pulpmills in the procurement of wood chips from sawmills. The pricing policies incorporate the transport costs involved in wood chip procurement, and determine to a very large extent the amount of chips utilized by the pulpmills. The pricing behavior, or conduct resulting from this imperfect market structure, therefore does have important implications on the utilization of these chips. However, because of the nature of the pulpmills input procurement, wood chips from sawmills and plywood and veneer mills compete directly with wood chips from company forest areas. As transport costs and pricing policy affect the cost of wood chips per BDU to the pulpmill, they therefore determine the competitiveness of wood chips from sawmill residues with wood fibre from company forest areas. This competition is enhanced by the opposing objectives of pulpmills and sawmills; that is a low price and a high price per BDU of chips respectively.

The trend, indicated by the data, is that the use of wood residues from sawmills, and plywood and veneer mills has increased, and that a uniform pricing system which transfers producer surplus or economic rent from near mills to far mills, results in a greater degree of wood chip utilization as inputs into pulp production, than the straight line system. This conclusion is strengthened by the relative use of wood chips from residues by the two pulpmills. Annual purchases of wood chips were 250,000 BDU for P&G and 50,000 BDU for NWPP in 1976. These levels of purchases of wood chips are also influenced by other factors. These include the relative locations of the pulpmills and sawmills, the altitude of the pulpmills management towards the procurement of wood chips, and the availability of timber.

The pareto-optimality condition as expressed by Whitcomb is where; "no increase in one commodity can be made without reducing some other commodity, given resource levels."[1] This optimum level of output on society's production frontier, cannot be achieved in one sector. Total utilization of wood chips alone, therefore, cannot achieve a pareto-optimality state. The trend towards increased utilization of wood chips and efficient use of resources is a move towards the optimum. It also results in an increase in value added from the harvest of the forest resource.

The pricing policies of the pulpmills and related transport costs do restrict the utilization of wood chips in Alberta. The combination of

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1. Whitcomb, D.K., Externalities and Welfare, (New York: Columbia University Press, 1972), p. 47. Note: as described on page 21, Chapter II, this is the socially desirable level to maximize benefits to society. This condition is an extension of the previous definition with respect to resource use and externalities.

transport costs and pricing determines how far chips may be transported. The uniform pricing system discriminates in favor of distant mills by transferring producer surplus from near mills to far mills. Such discrimination results in increased economic break-even distance and consequently greater utilization. The straight-line system, which prices according to cost of chips from company forest areas and transport costs, is not discriminatory. It does, according to the data, result in a lower level of wood chip utilization. The pricing systems evolved from the structure of the market for wood chips, and they have the greatest effect on the degree of utilization of wood chips in this study. The transport costs for rail and truck are inherent cost in wood chip purchases. The pricing system effected from these costs, the cost of obtaining wood chips from company forest areas, and the profit maximizing goals of the pulpmills' provides the market in which wood chip utilization is determined.

CHAPTER VI

SUMMARY AND CONCLUSION

The specific problem of concern in this study was to look at the marketing of wood chips from sawmills to pulpmills in Alberta, and find where the inefficiencies were to restrict wood chip utilization. The hypothesis was formulated to specific concerns in the marketing of wood chips which were thought to restrict utilization. Chapter II presented the economic theory on which the analysis and study is based. Chapter III discussed the forest industry in Alberta and some specifics on wood chips. Chapter IV presented the methodology used to collect primary data for the case studies and comparative analysis in Chapter V. This chapter serves as a summary of the major findings from the study, and discusses policy recommendations in view of these findings. As well, the need for further research is discussed.

The results of the comparative analysis in Chapter V provided an affirmative answer to the hypothesis. In view of this restriction of wood chip utilization by transport costs and pricing policies of the pulpmills, the general trend indicated is that residue use has increased; most noticeably under the uniform pricing system which transfers producer surplus from near mills to far mills. This restriction of utilization is viewed in terms of the percentage of standing timber transformed into final products. A socially optimum rate of utilization (pareto-optimum) of wood residues would result in the forest resource obtaining its maximum value-added. The pricing

policies and transport costs restrict the utilization in terms of quantity. To reach a pareto-optimum position would require direction of the forest resource toward various end-uses to achieve the maximum value-added. The restriction identified in this study does not necessarily result in a restricted position in terms of value-added. The results do, however, show how the pricing policies and transport costs affect the volume and flow of wood residue chips, and other primary products.

The directive for the end use of the forest resource stems from costs of acquiring inputs and prices received for sale of products at various levels in the productive stage. Transport costs affect the price of wood chips to the sawmill directly, under the straight-line system. In terms of what the pulpmill is prepared to pay for the chips as input, the transport costs affect the distance of haul. Under the uniform system, near mills subsidize the far mills, enabling a greater distance of haul. As well, the price is kept at a level which induces a reasonably stable supply of chips from the sawmills.

Policy Recommendations

The present rate of utilization of Alberta's forests are low. The existance of large surplus timber and the fact that only 50 percent of the wood residue material is being chipped for pulp places the industry in a relatively inefficient position. In considering policy alternatives for the industry, the results of this study and overall industry trends are included. The following policy recommendations are made in view of the study and are intended to serve as policy guidelines in the implementation of future industry

development plans, both in the short run and long run periods. They are as follows;

1. to conduct a comprehensive study on price levels for residue wood chips, sawlog and pulp log prices,
2. to improve and upgrade existing transportation and infrastructure facilities,
3. to look at regional disparities in terms of the forest products industry locations both currently and in the future.

The goal of the study on price levels is to establish a system for analyzing the effects of these price levels on utilization of the forest resource. Such effects as drawing good sawlogs or peeler logs into chip production should be considered. By analyzing the effects of price levels on the flow of the resource to various end-uses, it would be hoped to establish price levels which would result in maximum utilization, and guide the flow of the forest resource to end-uses which maximize value-added. If price is set at an artificially high level, then all of the log is chipped. British Columbia provides a convenient comparison. The minimum chip price policy in B.C., combined with a slump in the lumber market, resulted in a tremendous over production of chips. The market structure for wood chips in Alberta is different than in British Columbia, however interference in the market by setting too high a price floor could have damaging effects in overall forest utilization to various end-uses. A report by Pearse concluded that, "a minimum chip price policy should be designed to deal specifically where competition among buyers does not occur."[1] The result of this kind of price policy would be in reducing problem areas where chip

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1. Pearse, P.H., Timber Rights and Forest Policy in British Columbia, Vol. I., (Report of the Royal Commission on Forest Resources, Queens Printer, Victoria, 1976), p. 304.

production is damaging to the utilization of the residues and the forest resource. In view of the imperfect market structure with respect to wood chip buyers in Alberta, there is little competition. The differences in utilization rates between the two provinces is a result of more than just market structure. Other factors such as the location of sawmills with respect to one another, transportation facilities, and the large surplus of chips from British Columbia account for some of the differences. In a more general conclusion, the report of the Royal Commission on forest resources states, "policy should be directed toward increasing the demand for chips and competition among purchasers, in the interests of fuller and more efficient utilization of timber that must otherwise be wasted."[1] A study on price levels and their effects on the volume of wood residues utilized, would provide an indication on the direction policies could be aimed, towards achieving maximum and efficient utilization of the forest resource. The level where maximum and efficient utilization is achieved would depend on economic factors within the specific study area.

A policy to improve and upgrade existing transportation facilities would improve the physical marketing channels through which all products are now marketed. This policy would include studying the present infrastructure in view of its impediment to chip marketing as well as other products.

The policy recommending a look at regional disparities is a long term one. Though productive incentives and pricing can facilitate

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1. Ibid., p. 303.

efficient resource use, the importance of regional impacts from these other policies should not be overlooked. The constant overview of regional employment problems, and other disparities, is essential in developing equitable and efficient policies in view of overall resource utilization.

Need for Further Research

The need for further research to supplement and complete information gaps in this study is an on going concern. A study on alternative uses and their potential impact on the industry would be beneficial in providing marketing alternatives. A further study may look at contract arrangements in the procurement of wood chips. This is an important factor in setting prices and volume levels. The security which contracts could provide would be important in maintaining a long run supply of wood chips from residues.

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APPENDIX A

QUESTIONNAIRE - SAWMILLS

The procurement of primary data to test the hypothesis was achieved through the use of a mailed questionnaire.

The objective of the questionnaire was to find relevant information to accurately analyze the marketing of the chips. These, along with personal interviews and secondary information sources, provided the data used in this thesis study.

The questionnaire consists of nine questions, which were intended to provide data on: the primary product of the mill and its output; the volume of chips produced; the purchaser and price received for the chips; transportation modes for both lumber products and the chip by-product; information on burners; the original of the mill's raw material; and any opinions on alternate uses of waste wood chips. The data which was received provided a reasonable view of the marketing of wood chips. Some of the information was used to check the reliability of other data, and therefore, was not used directly. Other data estimates were not used because of a high degree of variability (for example, the chipping costs as noted in Chapter V).

The covering letter for the questionnaire as well as a follow-up (one week) letter is included in this appendix.

H. George Geldart
Graduate Assistant
Dept. of Rural Economy
University of Alberta
EDMONTON, Alberta
October 4, 1976

Dear Sir:

A research study is being carried out, which is looking at waste-wood chip marketing in Alberta, with major emphasis on the effect of transportation costs. The objective of this research is to provide an accurate analysis of chip marketing in the province, and to derive policy recommendations which might be used in improving the industry's present market situation. I believe this study is of interest to Alberta producers. The study has the support of the Secretary of the Alberta Forest Products Association.

Each individual firm's contribution will make an impact on the findings from the questionnaire. I sincerely hope that you will be able to assist me in obtaining the necessary data. Of course, any information which is obtained for the study will remain strictly confidential. All revealing figures will be shown in an aggregated form.

Would you please fill out the enclosed questionnaire, at your earliest convenience, and return it in the self-addressed envelope provided. Your time and effort would be very much appreciated.

Thanking you in advance for your co-operation.

Yours sincerely,

H. George Geldart
Graduate Assistant

SAWMILL - Questionnaire October, 1976.

1. PRODUCT

(a) Total Yearly Production (bd.ft.)

(b) Production per Shift (average)

(c) Lumber

Sizes Rough or Finished

2. WOOD CHIPS

(a) Do you have a chipper? ____. If so;

i) Make and Type:

ii) Year purchased

iii) Age when purchased

(b) Volume of Chips produced annually (units; bone dry: 1 unit = 2400 lb.)

(c) Would you please give an estimate of your chip output (cu.ft.) per thousand f.b.m. of production?

(d) Would you please give an estimated cost per thousand f.b.m. of producing wast-wood chips? (Dollars)

(e) Other waste meterials: Do you use them for anything other than burning? If so, please state volumes of:

i) Sawdust

ii) Planer Shavings

iii) Trimming Blocks

(f) What price do you receive for chips? (Dollars per bond dry unit)

(g) Who buys them? (i.e. Where do they go?)

i) Pulpmills: Proctor & Gamble - Grande Prairie ______

Northwestern - Hinton ______

IKO - Calgary ______

BP - Edmonton ______

ii) Others (Purchasers for Cattle bedding, Shingle manufacturing, etc.)

3. TRANSPORTATION

(a) Type(s) of loading process for chips.

i) Rail

ii) Truck

(b) Proportion of chips shipped by:

i) Rail ______%
ii) Truck ______%

(c) Proportion of Lumber shipped by:

i) Rail ______%
II) Truck ______%

4. TRANSPORT CARRIERS FOR CHIPS

(a) Rail (Please Check)

Canadian National Railway ______

Canadian Pacific Railway ______

Alberta Natural Resources Railway ______

Northern Alberta Railway ______

(b) Truck

i) Names of Common Carriers (Please Specify)

ii) If your chips are shipped by truck:

- What type of truck? (please include # of axles and road capacity)

- What are the weights: All season and winter. (i.e. How do the Provincial Weight Limits affect your trucks?)

5. TRANSPORT CARRIERS FOR LUMBER

(a) Rail (Please Check)

CNR ______

CPR ______

ANRR ______

NAR ______

(b) Truck

i) Names of Common Carriers (Please Specify)

6. How do you dispose of waste not used?

   (a) Burner:

      i) Size

      ii) Type

      iii) Age

      iv) Special Equipment (Pollution, etc.)

   (b) Other

7. Are there alternate markets for these waste-wood chips? If so, would you please explain.

8. I am interested in potential markets as well. Could you please state any ideas you have on the subject?

9. What is the origin of your Timber? (Please Specify)

   (a) Quota Number:

   (b) Other Sources:

H. George Geldart
Graduate Assistant
Dept. of Rural Economy
University of Alberta
EDMONTON, Alberta

Dear Sir;

This is just a reminder about the chip study questionnaire, sent to you a few weeks ago. It is very important to the study that we get as many of the questionnaires returned as possible. Would you please fill out at your earliest convenience and return it in the envelope that was provided.

Your assistance is much appreciated.

If you have already completed the questionnaire, please disregard this letter.

Yours sincerely,

H. George Geldart
Graduate Assistant

APPENDIX B

ALBERTA FOREST PRODUCTS ASSOCIATION LETTER OF SUPPORT

spruce
pine
fir

alberta forest products association
11710 kingsway avenue, edmonton, alberta T5G 0X5
telephone (403) — 452-2841

September 28th, 1976

Mr. H.G. Geldart
Graduate Assistant
Department of Rural Economy
University of Alberta
EDMONTON, Alberta

Dear Mr. Geldart:

The study you are conducting in support of your masters thesis concerned with the marketing of waste wood chips in Alberta, with emphasis on transportation, could be of interest to the industry here.

I trust that you will receive support from our membership in your endeavors to obtain economic data by means of interview and questionnaire which may be sent to them.

Yours very truly,

Arden A. Rytz
Secretary Manager

AAR/la

APPENDIX C

1. These calculations are based on answers received from the questionnaires and from Alberta Road User Costs: Update 1976. The tables used for variable and fixed costs are contained in this appendix.

   The following points were used in calculating transport costs:

   a) average trip speed of trucks for short haul (under 100 miles) was 10 miles per hour. This was based on hours of use from P&G.
   b) average trip speed for long hauls (greater than 100 miles) was estimated at 40 miles per hour.
   c) the average size of load from the data collected was 28 BDU, and varied from 25 to 30 BDU of chips.
   d) truck size was primarily 7-axle, and included some 5-axle units. Tractor units used are motor in front of cab types. These are noted to be more cost-efficient for hauls of the nature in wood chip transportation (this was noted in interviews conducted).
   e) a terminal charge of $1.30 per BDU was assumed for loading and unloading.
   f) fixed costs are constant, and variable costs per mile decrease slightly with distance.
   g) road surface: pavement and gravel are assumed to be in a 85 to 15 percent split respectively.
   h) road grade was not significant enough to include in calculations.

2. Assumptions made in Calculating break-even distance for truck haul of wood chips:

   a) average load of chips equalled 28 BDU.
   b) total costs equalled $0.79 per mile (this is estimated using fixed and variable costs from tables C-1 and C-2, and from questionnaire information).
   c) terminal charges equalled $1.30 per BDU.
   d) the cost of obtained wood chips from timber quotas for the pulpmill is $38.00 per BDU.
   e) trend from the data indicates the uniform pricing system effects a price of $20.00 per BDU, F.O.B. the sawmill.

Calculation:

$0.79/mile X 592 return trip miles = $467.68 total trip cost.

$467.68 ÷ 28 BDU = $16.70/BDU

$16.70 + $1.30 = $18.00/BDU

Price F.O.B. Sawmill + cost of transport = Cost of chips/BDU to the Pulpmill.

$18.00/BDU + $20.00/BDU = $38.00/BDU

Beyond this distance, the pulpmill pays more for chips than from company forest management areas.

TABLE C-1
VARIABLE AND FIXED COSTS (TRUCK)

PROVINCE: Alberta

CARRIER CATEGORY: Bulk Commodities

A. OPERATING STATISTICS

1. Payload Tons: 35 tons
2. One-way Miles: 200
3. Load Time: 1 hrs
4. Unload Time: 1 hrs
5. Total Trip Time: 12.6 hrs (Paved)
   14.2 hrs (Gravel)
6. Annual Miles: 100,000
7. Annual Hours: 3150 hrs (Paved)
   3550 hrs (Gravel)

B. ANNUAL OPERATING COSTS

PAVED HIGHWAY Total Cost	$ Per Hour	¢ Per Mile		GRAVEL ROAD ¢ Per Mile	$ Per Hour	Total Cost
			TRACTOR VARIABLE COSTS			
14,375	4.56	14.4	Driver Wage	16.3	4.59	16,280
1,725	.54	1.7	Driver Burden	1.9	.55	1,954
9,700	3.08	9.7	Fuel	9.7	2.73	9,700
4,700	1.49	4.7	Maintenance	5.6	1.58	5,600
1,800	.57	1.8	Tires	3.0	.84	3,000
100	.03	.1	Cleaning	.1	.03	100
800	.25	.8	Transport	.8	.22	800
33,200	10.54	33.2	TOTAL TRACTOR VARIABLE	37.4	10.54	37,434
			TRACTOR FIXED COSTS			
5,730	1.82	5.7	Depreciation	5.7	1.61	5,730
1,091	.35	1.1	Licence	1.1	.31	1,091
6,821	2.17	6.8	TOTAL TRACTOR FIXED	6.8	1.92	6,821
40,021	12.71	40.0	TOTAL TRACTOR	44.2	12.46	44,255
			TRAILER VARIABLE COSTS			
1,900	.60	1.9	Maintenance	2.3	.65	2,300
1,200	.38	1.2	Tires	2.0	.56	2,000
1,000	.32	1.0	Cleaning	1.0	.28	1,000
700	.22	.7	Transport	.7	.20	700
4,800	1.52	4.8	TOTAL TRAILER VARIABLE	6.0	1.69	6,000

TABLE C-1 (Continued)

TRAILER FIXED COSTS

3,080	.98	3.1	Depreciation	3.1	.87	3,080
---	---	---	Licence	---	---	---
3,080	.98	3.1	TOTAL TRAILER FIXED	3.1	.87	3,080
7,880	2.50	7.9	TOTAL TRAILER	9.1	2.56	9,080
1,308	2.44	7.7	TOTAL INSURANCE	9.0	2.53	1,928
7,680	.41	1.3	TOTAL ADMINISTRATION & INTEREST	1.9	.54	8,996
---	---	---	TOTAL PICK-UP & DELIVERY	---	---	---
56,889	18.06	56.9	TOTAL OPERATING COSTS	64.2	18.09	64,259

C. COST BASIS

1. Driver Per-mile Wage 11.2 ¢/mile.

2. Driver Per-hour Wage $ 4.23 /hour.

3. Fuel Cost 45.5 ¢/gallon (includes a carrier discount).

4. Pick-up and Delivery Driver Hourly Wage $_______ /hour.

Source: Trimac Consulting Services, An Evaluation of the Feasibility of Full Cost Disclosure in the Motor Carrier Industry, (Prepared for the Alberta Department of Industry and Commerce, December, 1974).

TABLE C-2

RUNNING COST AND TOTAL COST AT UNIFORM SPEED ON LEVEL TANGENTS

VEHICLE = TRT.TRUCK (5 AND MORE AX) ROAD SURFACE = HIGH TYPE
UNIT = DOLLARS PER 1000 VEH-MILES PAVEMENT IN GOOD CONDITION

SPEED MPH	FUEL	TIRES	ENGINE OIL	MAINTE-NANCE	DEPRE-CIATION	RUNNING COST	TIME COST	TOTAL COST
5.00	129.65	3.13	15.24	45.57	192.94	386.53	148.00	534.53
7.50	88.49	4.81	11.87	45.07	166.82	317.06	148.00	465.06
10.00	68.23	6.45	9.89	45.11	149.35	279.02	148.00	427.02
12.50	56.33	8.18	8.70	45.44	135.89	254.54	148.00	402.54
15.00	48.70	10.03	7.90	46.07	125.01	237.70	148.00	385.70
17.50	43.44	11.88	7.37	46.96	116.09	225.75	148.00	373.75
20.00	39.80	13.88	7.02	48.03	108.64	217.36	148.00	365.36
22.50	37.15	15.90	6.72	49.39	102.34	211.50	148.00	359.50
25.00	35.31	18.18	6.45	50.96	96.90	207.80	148.00	355.80
27.50	34.11	20.42	6.22	52.70	92.24	205.68	148.00	363.68
30.00	33.35	22.85	6.01	54.63	88.24	205.08	148.00	353.08
32.50	32.96	25.49	5.80	56.76	84.82	205.84	148.00	353.84
35.00	32.98	28.26	5.62	59.08	81.83	207.77	148.00	355.77
37.50	33.41	31.24	5.39	61.51	79.21	210.75	148.00	358.75
40.00	34.19	34.46	5.06	64.00	76.85	214.56	148.00	362.56
42.50	35.33	37.90	4.74	66.57	74.72	219.26	148.00	367.26
45.00	36.83	41.65	4.41	69.23	72.79	224.91	148.00	372.91
47.50	38.76	45.72	4.06	71.98	71.06	231.57	148.00	379.57
50.00	41.14	50.10	3.91	74.81	69.48	239.43	148.00	387.43
52.50	43.99	54.93	3.94	77.68	68.04	248.58	148.00	396.58
55.00	47.41	60.22	4.06	80.58	66.69	258.96	148.00	406.96
57.50	51.46	66.04	4.26	83.50	65.40	270.66	148.00	418.66
60.00	52.96	72.29	4.56	86.46	64.68	280.95	148.00	428.95

Source: Ashtakala, Bala (Dr.), _op. cit._, P. 24.

TABLE C-3

RUNNING COST AND TOTAL COST AT UNIFORM SPEED ON LEVEL TANGENTS

VEHICLE = TRT.TRUCK (5 AND MORE AX)
UNIT = DOLLARS PER 1000 VEH-MILES

ROAD SURFACE=
GRAVEL

SPEED MPH	RN.COST GRAVEL	TIME COST	TOTAL COST	GRAVEL FACTOR
5.00	436.78	148.00	584.78	1.13
7.50	370.96	148.00	518.96	1.17
10.00	337.62	148.00	485.62	1.21
12.50	318.17	148.00	466.17	1.25
15.00	304.26	148.00	452.26	1.28
17.50	295.73	148.00	443.73	1.31
20.00	289.09	148.00	437.09	1.33
22.50	287.64	148.00	435.64	1.36
25.00	286.77	148.00	434.77	1.38
27.50	287.95	148.00	435.95	1.40
30.00	291.21	148.00	439.21	1.42
32.50	296.40	148.00	444.40	1.44
35.00	303.34	148.00	451.34	1.46
37.50	311.91	148.00	459.90	1.48
40.00	321.84	148.00	469.84	1.50
42.50	333.27	148.00	481.27	1.52
45.00	346.37	148.00	494.37	1.54
47.50	358.93	148.00	506.93	1.55
50.00	375.91	148.00	523.91	1.57
52.50	395.24	148.00	543.24	1.59
55.00	416.92	148.00	564.92	1.61

Source: Ashtakala, Bala (Dr.), *op. cit.*, P. 25.